INSTRUCTION MANUAL

COHERENT DECADE FREQUENCY SYNTHESIZERS

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GENERAL RADIO COMPANY

West Concord, Massachusetts

OPERATING INSTRUCTIONS

COHERENT DECADE FREQUENCY SYNTHESIZERS

Type 1161-A Type 1162-A Type 1163-A

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GENERAL RADIO COMPANY

West Concord, Massachusetts

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SPECIFICATIONS

	Type 1161-A	Type 1162-A	Type 1163-A
Frequency Range:	0-100 kc/s	0-1 Mc/s	30 c/s-12 Mc/s
Smallest Digital Step:	0.01 c/s	0.1 c/s	1 c/s
Smallest Direct-Calibrated CAD Increments (A7C-models only):	0.0001 c/s	0.001 c/s	0.01 c/s
Max Bandwidth Controllable by CAD:	100 kc/s	1 Mc/s	1 Mc/s
RDI-1 Units may be used in:	All digit positions		All except 1-Mc step position
Spurious Frequency Outputs: **Harmonic (at max output):**	<-40 dB	<-40 dB	<-34 dB
Nonharmonic:	<-80 dB	<-60 dB	<-60 dB
Output:	**Coupling switch at AC:** Adjustable, 0 to 2 V, rms; metered at output receptacle (internal impedance ≈ 7 Ω; min load impedance for full power = 50 Ω).		**Output impedance switch at 50 Ω:** 0 to 2 V, rms; metered; behind 50 Ω.
	Coupling switch at DC: Adjustable, 0 to 0.8 V, rms; not metered. (Source impedance variable up to about 4 kΩ with level setting.)		**Output impedance switch at 0:** 0 to 2 V, rms; metered at output receptacle after low impedance.
Output Frequency Characteristic:	±1 dB max, 50 c/s to max frequency (across 50-Ω or higher load, ac-coupled). ±0.2 dB max, 0 to 10 kc/s (dc-coupled).		±1.5 dB max, 50 c/s to 12 Mc/s; 50-Ω load.

AVAILABLE AUXILIARY OUTPUTS (rear of instruments)

Primary Outputs, All Three Types: 100 kc/s and 5 Mc/s (0.5 V, rms, min, across 50 Ω).

Secondary Outputs: 0.1 V, min, across 1 kΩ.

All Three Types	*Type 1162-A*	*Type 1163-A*
1.0 Mc/s 5/5.1 Mc/s 42 Mc/s +18 V dc (test point or limited-current source)	50 Mc/s 50/51 Mc/s	39 to 50 Mc/s (1-Mc steps); 50/51 Mc/s

FOR ALL THREE TYPES

Operating Temperature Range: 0 to 50°C.

Internal Frequency Standard: Room-temperature, quartz-crystal oscillator. Temperature coefficient of frequency is typically less than 2×10^{-7}/°C from 20°C to 50°C. A front-panel frequency adjustment is provided. Crystal can easily be phase-locked to an external standard.

Lock Signal Input from external standard (if used): 0.25 V, rms, to 5 V, rms, 5 Mc/s, or any submultiple down to 100 kc/s. Input impedance is approximately 1 kΩ for low-level signals; drops to approximately 50 Ω effective at high level.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 400 c/s, 55 W; or 20 to 28 V dc, 1.8 A.

Accessories Supplied: Type 874-R22LA Coaxial Patch Cord, Bridging Unit (maintenance substitute for DI), Panel Insert for use with Bridging Unit, Type CAP-22 3-wire power cord, spare dial lamps and fuses.

Terminals: Locking GR874 coaxial, Type 938 Binding Post, BNC, and miniature coaxial.

Cabinet: Rack-bench; end frames for bench mount and fittings for rack mount are included.

Mechanical Data: Rack-Bench Cabinet

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	5¼	135	15½	395	38	17.5	45	20.5
Rack	19	485	5¼	135	13*	330	38	17.5	45	20.5

* Behind panel.

U. S. Patent No. 2,548,457. Patents Pending.

General Radio Experimenter references: 38, 9, September 1964; 39, 5, May 1965; 39, 11 & 12, November-December 1965

Type 1161-A

0–100 kc/s

Type 1161-A7C

Type 1162-A

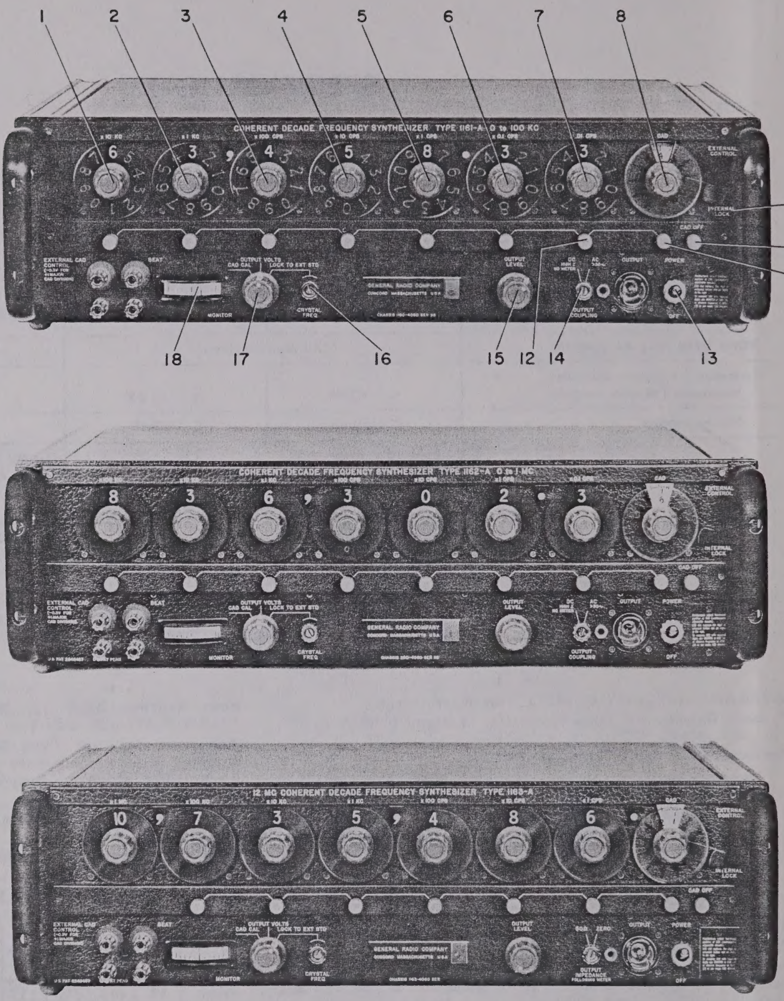
0–1 Mc/s

Type 1162-A7C

Type 1163-A

30 c/s–12 Mc/s

Type 1163-A7C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COHERENT DECADE FREQUENCY SYNTHESIZER TYPE 1161-A 0 to 100 KC
COHERENT DECADE FREQUENCY SYNTHESIZER TYPE 1162-A 0 to 1 MC
12 MC COHERENT DECADE FREQUENCY SYNTHESIZER TYPE 1163-A
EXTERNAL CONTROL
INTERNAL LOCK
CAD OFF
EXTERNAL CAD CONTROL
BEAT
MONITOR
OUTPUT VOLTS
CAD CAL
LOCK TO EXT STD
CRYSTAL FREQ
GENERAL RADIO COMPANY
OUTPUT LEVEL
OUTPUT COUPLING
OUTPUT
POWER
OFF

Note: Only the basic type-number designation appears on any instrument.
Model variations must be determined by reference to Table 1-1.

Figure 1-1. Coherent Decade Frequency Synthesizers, full systems with all modules in place. Remotely programmable versions look the same from this view except that programmable step-digit dials have an eleventh position marked "R". The callouts refer to Table 1-2.

SECTION 1

INTRODUCTION

1.1 PURPOSE.

The Types 1161-A, 1162-A, and 1163-A Coherent Decade Frequency Synthesizers are highly accurate oscillator systems with a direct decimal-digit readout. Each permits frequency selection precise in up to nine significant figures.

The frequency of the output signal is synthesized by proper combinations of a number of frequencies, each of which is derived from a single internal master frequency. Since each of the frequencies used for the synthesizer is derived (on a proportional basis) from this crystal-oscillator source, the output is always coherent in frequency with that of the source and has the same percentage accuracy as the source.

Frequencies are selected by means of a series of from three to seven stepped-digit units plus a continuously adjustable decade (an optional module in any version of any system). Figures 1-1 and 1-2 are indicative of the system variations possible. Remote programming capability is standard for the continuously adjustable unit; it is optional for stepped decades.

The synthesizers are essential in applications requiring stable, sine-wave signal sources capable of ultraprecise frequency adjustment through wide frequency regions. They are also convenient for less demanding uses.

The output frequency is readily applied to automatic recording of the frequency response of networks and the frequency drift of oscillators. Frequency markers can be formed with the aid of built-in calibration circuitry of enhance these functions.

1.2 DESCRIPTION.

1.2.1 PERFORMANCE CHARACTERISTICS.

Any member of the Type 1161-A Coherent Decade Frequency Synthesizer group supplies frequencies from 0 to 100 kc/s in step increments. A fully equipped instrument has digit steps as small as 0.01 c/s and also includes a continuously adjustable decade that can be switched in beyond the smallest discrete step, or at any point in the digit series.

The Type 1162-A group is nearly identical, except that the maximum frequency is 1 Mc/s and the smallest discrete step is 0.1 c/s. Types 1161-A and 1162-A use a common chassis, thus one type can be transformed to the other by module changes.

The Type 1163-A group generates frequencies up to 12 Mc/s, with digit steps as small as 1 c/s. The Main Frame for the Type 1163-A, although possessed of the same dimensions and form factor as the Types 1161/1162 Main Frame, differs in some details and is not interchangeable.

Heart of each of the synthesizers is a set of up to seven identical, locally controlled, plug-in modules, called DI (for Digit-Insertion) units. Alternative assemblies use RDI units which are capable of either local or remote control.

All frequencies are derived from a single, built-in, 5-Mc, room temperature, crystal oscillator. For maximum accuracy, this oscillator can be phase locked to an external frequency standard operating at 5 Mc/s or any submultiple thereof, such as the General Radio Type 1115-B Standard-Frequency Oscillator. Refer to paragraph 1.6.1.

The continuously adjustable decade (CAD) develops a frequency, adjustable smoothly through a digit decade, that can be standardized by comparison with the output of the DI units.

Operation of the synthesizers is simple and straightforward. The rotary switches are set so that the desired frequency is indicated by rear-lit, in-line numerals. Fixed comma and decimal-point indicators are included in the readout.

Used to supplement the frequency determined by the digital setting, the CAD can, theoretically, be

TABLE 1-1
EQUIPMENT CONFIGURATIONS

TYPE 1163-A COHERENT DECADE FREQUENCY SYNTHESIZER 30 c/s to 12 Mc/s

Local Control, or Remotely Programmable Type*	Local Control Only Type	Units Included	Calibrated Digits		Smallest Step (Digits Only)
			Decades Only	Decades + CAD**	
1163-AR7C	1163-A7C	7 DI Units + CAD	7	9	1 c/s
1163-AR6C	1163-A6C	6 DI Units + CAD	6	8	10 c/s
1163-AR5C	1163-A5C	5 DI Units + CAD	5	7	100 c/s
1163-AR4C	1163-A4C	4 DI Units + CAD	4	6	1 kc/s
1163-AR3C	1163-A3C	3 DI Units + CAD	3	5	10 kc/s
1163-AR7	1163-A7	7 DI Units	7		1 c/s
1163-AR6	1163-A6	6 DI Units	6		10 c/s
1163-AR5	1163-A5	5 DI Units	5		100 c/s
1163-AR4	1163-A4	4 DI Units	4		1 kc/s
1163-AR3	1163-A3	3 DI Units	3		10 kc/s

TYPE 1162-A COHERENT DECADE FREQUENCY SYNTHESIZER 0 to 1 Mc/s

Local Control, or Remotely Programmable Type	Local Control Only Type	Units Included	Calibrated Digits		Smallest Step (Digits Only)
			Decades Only	Decades + CAD**	
1162-AR7C	1162-A7C	7 DI Units + CAD	7	9	0.1 c/s
1162-AR6C	1162-A6C	6 DI Units + CAD	6	8	1 c/s
1162-AR5C	1162-A5C	5 DI Units + CAD	5	7	10 c/s
1162-AR4C	1162-A4C	4 DI Units + CAD	4	6	100 c/s
1162-AR3C	1162-A3C	3 DI Units + CAD	3	5	1 kc/s
1162-AR7	1162-A7	7 DI Units	7		0.1 c/s
1162-AR6	1162-A6	6 DI Units	6		1 c/s
1162-AR5	1162-A5	5 DI Units	5		10 c/s
1162-AR4	1162-A4	4 DI Units	4		100 c/s
1162-AR3	1162-A3	3 DI Units	3		1 kc/s

TYPE 1161-A COHERENT DECADE FREQUENCY SYNTHESIZER 0 to 100 kc/s

Local Control, or Remotely Programmable Type	Local Control Only Type	Units Included	Calibrated Digits		Smallest Step (Digits Only)
			Decades Only	Decades + CAD**	
1161-AR7C	1161-A7C	7 DI Units + CAD	7	9	0.01 c/s
1161-AR6C	1161-A6C	6 DI Units + CAD	6	8	0.1 c/s
1161-AR5C	1161-A5C	5 DI Units + CAD	5	7	1.0 c/s
1161-AR4C	1161-A4C	4 DI Units + CAD	4	6	10 c/s
1161-AR3C	1161-A3C	3 DI Units + CAD	3	5	100 c/s
1161-AR7	1161-A7	7 DI Units	7		0.01 c/s
1161-AR6	1161-A6	6 DI Units	6		0.1 c/s
1161-AR5	1161-A5	5 DI Units	5		1.0 c/s
1161-AR4	1161-A4	4 DI Units	4		10 c/s
1161-AR3	1161-A3	3 DI Units	3		100 c/s

*First decade not programmable.

**Direct reading (without calibration of CAD). If CAD is calibrated in terms of the step decades, at least one more significant figure can be added.

TABLE 1-2
CONTROLS AND INDICATORS – ALL SYSTEMS (See Figure 1-1)

REF Fig 1-1	*Name*	*Type*	*Function*	*Related Indicator*	*Remarks*
1 through 7	Digit-Insertion Dial — Stations I-VII	Rotary switch, 10-position (12-position in first station of Type 1163-A)	Select digits of readout	Numeral at dial top center (illuminated)	In Remotely Programmable system, switch has an added position marked "R".
8	CAD (Continuously Adjustable Decade)	Capacitor, rotary adjustment	Supplement to step digits or substitute for a group of Digit-Insertion units	Continuously calibrated dial; also MONITOR meter with switch in CAD CAL position, or signal at BEAT for any monitor-switch position.	Used only in systems with C suffixes, e.g., -A6C, -AR6C.
9	CAD Mode Control — EXTERNAL CONTROL and INTERNAL LOCK	Coaxial lever switch, 2-position	Permits electronic control of CAD frequency when in EXTERNAL CONTROL position	Illuminated sector on CAD dial (dimmed in EXTERNAL CONTROL position)	
10	CAD OFF	Latching, 2-position push-button; combined rf and lamp-control switch	Places CAD on standby when actuated	Dial sector not illuminated with CAD OFF button actuated	CAD, while not contributing to output, is still warmed up and on standby.
11	CAD enable control	Latching, 2-position push-button; combined rf and lamp-control switch	Connects CAD at end of train of installed DI units	Dial sector illuminated when CAD is in use	Dial also illuminated when any of buttons (12) actuated.
12	Digit Disable Controls — Stations I-VII (II-VII in Type 1163-A)	Latching, 2-position push-buttons; combined rf and lamp-control switches	Disable Digit-Insertion units above and to the right when latched in depressed position	Digit illumination extinguished at disabled DI units.	On CAD-equipped systems, CAD substitutes for disabled units. All disabled digits are replaced by 0's, if the CAD is not installed.
13	POWER	Toggle switch, 2-position	Main ac power-input control	Dial of active DI units illuminated when power is on	
14	OUTPUT COUPLING (AC or DC coupling for Types 1161/1162) OUTPUT IMPEDANCE (0 or 50 ohms for Type 1163-A)	Screwdriver-actuated, 2-position switch	Change output coupling network	MONITOR meter with switch in OUTPUT VOLTS position-scale reads 0 — 2 volts, rms	No meter indication with DC coupling. Output falls off below 30 c/s in AC position.
15	OUTPUT LEVEL	Rotary potentiometer	Control level of output signal	MONITOR meter (set to OUTPUT VOLTS)	
16	CRYSTAL FREQ	Rotary potentiometer	Fine control of free-running frequency of master crystal oscillator	MONITOR meter, in LOCK TO EXT STD position, if external standard is connected	External standard (5 Mc/s or submultiple) applied to rear-apron connector (J107). Meter shows locking voltage developed in phase detector, which locks internal crystal to external standard.
17	MONITOR control	Rotary switch, 3-position	Selects function to be monitored	MONITOR meter	
18	MONITOR	Edgewise-type meter	Calibrated 0 to 2 for OUTPUT VOLTS. Also used around center scale, for CAD CAL and LOCK TO EXT STD functions.	None	In CAD CAL position, pointer homes at center scale as frequency equality is approached, then beats at low difference frequency. In LOCK TO EXT STD position, shows amplitude and sense of locking voltage.

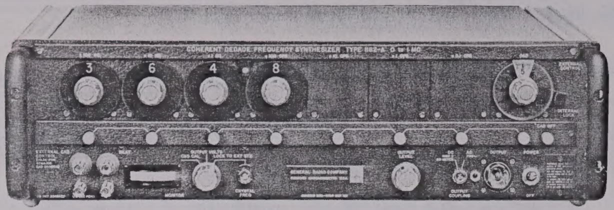

Figure 1-2. Type 1162-A4C synthesizer. Note the three missing Digit-Insertion units at the right and the three blank dress panels.

set to a resolution of better than 0.0001 c/s in the Type 1163-A, 0.00001 c/s in the Type 1162-A, and 0.000001 c/s in the Type 1161-A. The usable resolution is determined by oscillator stability and the time interval of interest (refer to paragraph 3.3.4).

Front-panel selection of ac or dc output coupling is provided in the Types 1161-A and 1162-A. When ac coupling is used, output voltage is indicated by the front-panel meter and is adjustable up to 2 volts into 50 ohms. Lower-level dc-coupled output, without meter indication, can be selected, when operation below 30-cycle output signal is necessary.

In the Type 1163-A dc-coupled output is not available. In units of this group, the panel meter reads output voltage either behind a 50-ohm resistor or directly at the output connector, as determined by the setting of a screwdriver-operated panel switch.

In all three types, the meter is also used:

1. to calibrate the CAD against any selected series of frequency digits set on the step-digit dials;
2. to confirm phase lock to an external standard, when such standard is connected.

The frequency of the CAD can be varied manually or by a dc-coupled external voltage for:

1. swept-frequency output;
2. narrow-band frequency modulation;
3. phase lock of the synthesizer output to external signals.

A magnified indication of the variation in synthesizer output frequency resulting from such intentional CAD variations is available at front-panel terminals, and also at the rear connector (refer to paragraphs 1.6.3 and 3.3.3).

1.2.2 MODULAR PACKAGING.

Each synthesizer, a completely self-contained frequency-generation system of modular construction, is supplied in several different configurations, as listed in Table 1-1. The variations permit the user to preselect the frequency range and the number of significant figures required in the readout for his particular application. At any time, a less-than-complete system can be expanded by the addition of plug-in modules available from General Radio.

A minimal system consists of a standard relay-rack-width chassis, known as the Main Frame, to which are attached a Power Supply unit, an Ancillary Frequency Source, an Output Mixer, and three Digit-Insertion units. All units plug in and the Digit Insertion units are interchangeable. Refer to paragraph 5.4 for mechanical details. Chassis 1160-4060 serves as the Main Frame for Types 1161-A and 1162-A; Chassis 1163-4060 is used in the Type 1163-A.

Optional extra modules include additional Digit-Insertion units and the Continuously Adjustable Decade unit (CAD). When the CAD is installed, a Calibrating Mixer unit (supplied with the CAD) is also plugged in.

Either of the Main Frames has all switching, connector, and other capabilities built in, so that no rewiring or panel drilling is necessary to change digit capacity by the addition of modules. Also, Types 1161-A and 1162-A can be changed from one to the other by the change of one plug-in module.

The specific hardware difference between these systems consists in the plug-in output mixer modules and corresponding front-panel frequency-step identification strips. The Type 1161-A Output Mixer operates at 5 Mc/s, whereas in the Type 1162-A, a 50-M Output Multiplier-Mixer unit is used. Both modules use the same interconnections and occupy the same space at the rear of the chassis.

The Output Multiplier-Mixer of the Type 1163-A mixes a 50/51-Mc continuously adjustable input and an input selectable in 1-Mc steps, by the left-hand frequency dial, from 50 Mc/s to 39 Mc/s.

Solid-state circuits are used exclusively for compactness and performance stability.

Front-panel controls and indicators permit rapid system self-check without recourse to internal test points or adjustments (refer to paragraph 5.3).

As normally supplied, the systems are fitted out for bench-top use but can be quickly converted for rack installation with a screwdriver. Refer to paragraph 2.1 for details.

1.3 CONTROLS AND INDICATORS.

Front-panel controls and indicators common to the three synthesizer groups are listed and described in Table 1-2. See also Figure 1-1.

1.4 CONNECTORS.

Commonly used connectors for attachment of the synthesizer to other equipments are listed and described in Table 1-3. These connectors are GR874 quick-connect, hermaphroditic, coaxial types. In each instance, locking versions of the connector are installed. These will accept either locking or nonlocking cable connectors.

In addition, certain synthesizer frequencies, which will be useful in connection with future ancillary equipment, are available at subminiature coaxial connectors at the rear of the Main Frame deck. They are listed in Table 1-4 (see Figures 1-1 and 2-2). The main output connector and the CAD control input and monitor are paralleled by BNC connectors at the rear.

TABLE 1-3
PRIMARY CONNECTORS

Name	*Ref Desig*	*Type*	*Function*	*Location*	*Remarks*
OUTPUT	J405	GR874 coaxial	Low-loss, quick-connect terminal for output signal.	Front panel	Adaptable; refer to paragraph 1.6.7.
	J405A	BNC	Same.	Rear Bracket	
BEAT	J403	Type 938 binding posts	Terminal for external observation of CAD calibration (magnified measure of CAD frequency departure from replaced digit dials).	Front panel	Type 274-NL Patch Cord recommended accessory.
	J403A	BNC	Same.	Rear Bracket	
EXTERNAL CAD CONTROL	J401	Type 938 binding posts	Terminals for injection of external voltage to vary CAD frequency.	Front panel	0.3 Vdc equivalent to 1 major CAD dial division.
	J401A	BNC	Same.	Rear Bracket	
LOCK SIG IN	J107	GR874 coaxial, locking	Terminal for injection of 5-Mc signal (or submultiple) from external frequency standard or from another synthesizer.	Rear apron (part of AFS unit)	Type 874-R22LA Patch Cord recommended accessory.
5 MC OUT	J108	GR874 coaxial, locking	Terminal for auxiliary 5-Mc signal output.	Rear apron (part of AFS unit)	Type 874-R22LA Patch Cord recommended accessory.
100 KC OUT	J206	GR874 coaxial, locking	Terminal for auxiliary 100-kc signal output.	Rear apron (part of AFS unit)	Type 874-R22LA Patch Cord recommended accessory.

TABLE 1-4
AUXILIARY CONNECTORS

Name	*Ref Desig*	*Function*	*Remarks*
5/5.1	J150	Signal output to ancillary equipment; test point. Frequency in Mc/s.	Subminiature coaxial connectors at rear edge of Main Frame deck.
5.0	J151		
1.0	J152		
42	J155		
50/51	J154		J154 and J156 present but not energized in Type 1161-A synthesizers.
50 *	J156		
5/5.1 REF	J157		
+18 V	J153	+18 V dc test point.	

*In Type 1163-A, J156 furnishes 50 to 39 Mc/s in 1-Mc steps.

1.5. ACCESSORIES SUPPLIED (Refer to Table 1-5).

TABLE 1-5
ACCESSORIES SUPPLIED

Item	*Type*	*Quantity*	*Function*	*Part Number*
Fuse	3AG/Slo-Blo (0.8A)	2	Spare for 115-V systems only	5330-1200
Fuse	3AG/Slo-Blo (0.4A)	2	Spare for 215/230-V systems only	5330-0900
Fuse	GMW (2A)	2	Spare for F503	5330-5020
Lamp	No. 327 (28V at 0.04A)	8	Spare for front-panel readout stations.	5600-0307
Bridging Unit	Plug-in	1	Spare. Completes circuits in Digit-Insertion station when active module is removed.	1160-4070
Cover Panel	Blank	1	Spare. Covers hole in front panel that results if a frequency-control module is removed.	1160-8015
Relay-rack mounting kit	Steel	1	Furnishes shelf support and necessary hardware to mount instrument in standard 19-inch relay rack.	7863-9632
Power cord	Rubber-molded, 3-wire, 7 feet long	1	Connect instrument to ac power. Rated 7A at 230 V.	4200-9622
Patch cord	Type 874-R22LA, coaxial, 3 feet	1	Connect LOCK SIG IN connector to Type 1115-B frequency standard, or use at OUTPUT connector.	0874-9683

1.6 ACCESSORIES AVAILABLE.

1.6.1 STANDARD-FREQUENCY OSCILLATOR – TYPE 1115-B.

This standard meets all the requirements for a stable laboratory standard of frequency for the calibration or phase-locking control of the synthesizer output.

Its oscillator uses a 5th-overtone, 5-Mc crystal in a single-stage, proportional-control oven which maintains the crystal temperature within a few millidegrees centigrade.

A front-panel control, calibrated directly in parts in 10^{10}, allows fine control of the oscillator frequency.

The sine-wave output at 5 Mc/s, available at the rear apron, can deliver a suitable locking signal to J107 (LOCK SIG IN) at the rear of the synthesizer. A Type 874-R22LA Patch Cord is recommended for this connection. Any load from open circuit to short circuit can be connected to the output with minimal effect on the oscillator frequency.

The standard normally operates from an ac supply or, in the event of power failure or disconnection of power for up to 35 hours, from an internal, pressure-relief-type, nickel-cadmium battery supply.

1.6.2 FREQUENCY METER AND DISCRIMINATOR – TYPE 1142-A.

This analog-type frequency meter measures frequencies from 3 c/s to 1.5 Mc/s with an over-all accuracy of ±0.2%, and can be used with a recorder to produce time records of frequency change or drift.

The Type 1142-A frequency meter input connects to the front-panel binding posts marked BEAT on the synthesizer, via a Type 274-NL Patch Cord. It presents a highly magnified indication of the departure of the synthesizer output frequency from that displayed on the digit dials as the CAD frequency, when substituted for the step digits, is adjusted either manually or electrically. Refer to paragraph 3.3.3.

The precision six-inch meter is accurate to 1% of indication down to 10% of full scale. A calibrated interpolation technique effectively expands the meter scale by a factor of 10, providing a readout accuracy of 0.1%.

1.6.3 SYNTHESIZER CONVERSION KITS.

Two kits are available to permit direct and rapid conversion of a Type 1161 synthesizer into a Type 1162, and vice versa. The conversion is a plug-in process that requires no rewiring or other permanent alteration. Thus, a converted synthesizer can be easily changed back to its original form. The converted instrument is complete and finished looking and indistinguishable in panel marking and every other respect from an unconverted synthesizer. Conversion in this manner from Types 1161 and 1162 to Type 1163 is not possible, however.

The kits are:

Type 1160-3040 Conversion Kit – Consists of an OMM-1 Output Multiplier-Mixer module and front-panel dial identification strip and is used to convert Type 1161 into Type 1162.

Type 1160-3030 Conversion Kit – Consists of an OM-1 Output Mixer module and front-panel dial identification strip and is used to convert Type 1162 into Type 1161.

Installation details are given in Section 5.

1.6.4 COAXIAL ADAPTORS.

As with similar General Radio equipment, the synthesizers use the quick-connect GR874 coaxial connector. However, for the user wishing to mate the instruments with components fitted with coaxial connectors of some other series, it is a simple matter to adapt to that series.

GR874 adaptors to leading commercial and military coaxial series (or to binding posts) are available to convert to the desired type. These adaptors are listed in Table 1-6.

Because the OUTPUT connector is recessed in the front panels an adaptor will protrude less than one inch beyond the panel. Over-all VSWR of the converted GR874 connector is typically no greater than that of the other-series connector by itself, and leakage at the GR874 junction is typically >120 dB down.

TABLE 1-6

TYPE 874 LOCKING COAXIAL ADAPTORS TO OTHER SERIES

Adapts to Type	*Type*	*Contains GR874 and ...*	*Connects GR874 to ...*	*Part Number*
BNC	874-QBJL	BNC Jack	BNC Plug	0874-9701
C	874-QCJL	C Jack	C Plug	0874-9703
Microdot	874-QMDJL	Microdot Jack	Microdot Plug	0874-9721
N	874-QNJL	N Jack	N Plug	0874-9711
OSM/BRM	874-QMMJL	OSM/BRM Jack	OSM/BRM Plug	0874-9723
SC	874-QSCJL	SC Jack	SC Plug (Sandia)	0874-9713
TNC	874-QTNJL	TNC Jack	TNC Plug	0874-9717
UHF	874-QUJL	UHF Jack	UHF Plug	0874-9719
274	874-Q2	Binding Posts	Type 274 Plug	0874-9870

SECTION 2

INSTALLATION

2.1 MOUNTING.

The synthesizer is fitted with rubber-footed aluminum end frames for bench use. Each end frame is attached to the instrument with two panel screws and four 10-32 Phillips-head screws with notched washers.

For a rack-mounting option, special brackets and hardware are furnished to attach the instrument and its cabinet to a standard 19-inch relay rack (see Figure 2-1). These brackets permit either cabinet or instrument to be withdrawn independently.

To install the instrument in a relay rack:

a. Remove the synthesizer from its cabinet; first, remove the four knurled front-panel screws, accessible through the clearance holes in the handles, and release the cabinet clamps at the rear.

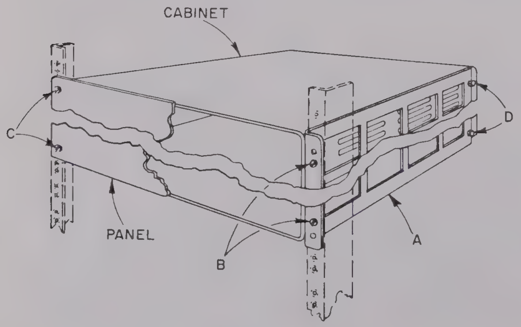

Figure 2-1. Relay-rack installation.

b. Remove the end frames from the cabinet with a Phillips-head screwdriver.

c. Attach each mounting bracket (A) to the rack with two 12-24 round-head screws (B). Use the inside holes on the bracket flange; the flange must be in front of the rack rail. The shelf lip must face in.

d. Slide the empty cabinet into the brackets until the edge of the front opening is flush with the rack rail.

e. Install the knurled screws (D), supplied with the brackets, in each side of the cabinet, through the slots in the rear of the bracket.

f. Slide the instrument into the cabinet, and tighten the rear clamps, if desired.

g. Insert the four knurled screws with attached washers (C) through the panel and the bracket and thread them into the rack. The washers are provided to protect the face of the instrument.

To remove the instrument from the rack, remove only the four panel screws (C) and slide the instrument forward out of the rack. To remove the cabinet and leave the instrument mounted in the rack, loosen only the thumb screws (D) at the rear of the brackets and pull the cabinet back off the instrument from the rear of the rack. Rear clamps, if used, must be released or tightened appropriately.

2.2 POWER CONNECTION (Figure 2-2).

2.2.1 AC POWER.

Use the power cord provided to connect the synthesizer to a source of power, as indicated on the plate near the input socket at the rear of the instrument. The long cylindrical pin (ground) makes direct contact to the metal frame of the instrument.

While instruments are normally supplied for 115-volt operation, the power transformer can be reconnected for 215- or 230-volt service (refer to the separate detailed instructions on the Power Supply). If power connections are changed, be sure to indicate on the chassis the correct input voltage and replace the line fuses with properly rated units.

2.2.2 DC POWER.

The instrument can be operated from a battery supply of 20 to 28 volts, at 1.8 amperes. To so operate, remove the normal ac input-power cord and connect the positive side of the battery to a plug, part no. 4270-0900, or a metal pin 0.050 inch in diameter for insertion in J551 in the rear panel of the Power Supply module. The negative side of the battery must be connected directly to the instrument frame. If a power ON-OFF switch is desired, it must be inserted in the external wiring – the panel switch is not in circuit.

NOTE

> The external dc supply should be of low impedance, such as is provided by a battery; otherwise, the internal regulator circuits may not start. If a poorly regulated dc supply must be used, the regulator can usually be started by momentary connection of J552 to the positive side of the supply, after it has come up to rated voltage.

2.3 ENVIRONMENTAL CONSIDERATIONS.

2.3.1 TEMPERATURE.

The synthesizer will operate within specifications in ambient temperatures ranging from 0 to 50°C.

2.3.2 MAGNETIC FIELDS.

Care has been taken to minimize effects of internal power-line-frequency magnetic fields on the quality of the output signal. There are, however, many ferrite-tuned and ferrite-shielded tuned circuits in the instrument, and magnetic fields from other equipments mounted nearby can, if strong enough, produce phase-modulation effects which will degrade the output signal. If power-line sidebands must be minimized, care must be taken to keep equipments that generate large external fields well separated from the instruments, or suitable magnetic shielding must be interposed.

2.4 DISTRIBUTION OF AUXILIARY FREQUENCIES.

GR874 coaxial terminals mounted on the rear apron of the instrument permit two fixed-frequency signals of 5 Mc/s and 100 kc/s to be taken from the synthesizer. Both are frequency coherent with the output signal and are well isolated to prevent unwanted loading effects. (See Figure 2-2).

One application of these terminals is to use the 5-Mc signal of one synthesizer to phase-lock the internal crystal oscillator of a second synthesizer. This can be accomplished by interconnection of the 5-MC terminal of the first instrument with the LOCK SIG IN terminal of the second. A Type 874-R22LA Patch Cord is recommended for the interconnection. Refer to paragraph 3.5 for the phase-lock procedures.

2.5 SYSTEM ALTERATION.

If your synthesizer was originally purchased as a partially complete system, the missing modules for the Digit-Insertion and/or CAD stations can be added, one at a time or as a group. No special tools are required and the change can be accomplished in minutes, with no need for rewiring or metal cutting. Retain as maintenance spares the blank panel cover and the DI Bridging Unit removed from activated stations. Refer to paragraph 5.4 for mechanical details.

2.6 REMOTE-CONTROL DIGIT INSERTION UNITS.

If the system as procured makes use of the Remote-Control Digit-Insertion unit, RDI-1, in place of the local control DI-1, consult the separate section of this book devoted to the RDI-1 for description and installation instructions. RDI-1 units can be substituted for DI-1 units at any time, by direct plug-in interchange.

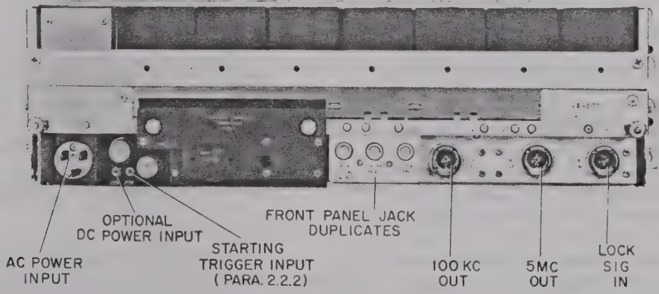

Figure 2-2. Rear view of the Type 1163-A7C Synthesizer with cabinet removed.

SECTION 3

OPERATING PROCEDURE

3.1 EQUIPMENT TURN-ON.

Operation of the Coherent Decade Frequency Synthesizer to generate precision-frequency sine waves is quite straightforward. All that is necessary is to apply power, set the frequency dials to the desired frequency, and adjust the signal at the OUTPUT connector with the OUTPUT LEVEL control. The output voltage is measured by the MONITOR meter when the MONITOR switch is set at OUTPUT VOLTS. The output frequency is displayed by the dials.

NOTE

> If the synthesizer is equipped with remotely programmable digit units, RDI-1, the corresponding dials have the ten digit positions 0 to 9 plus an eleventh position marked "R". When the dial is placed in the R position at any digit location, control of that digit is transferred to switching or other circuits that may be plugged into the connector at the rear of the digit unit. Refer to the separate section of this book on the RDI-1 unit for details. At any of the numbered dial positions, however, control remains with the local dial.

3.2 EQUIPMENT WARM-UP.

Since the equipment is all solid-state except for the dial lamps, no warm-up time is required to generate output. However, in applications where the synthesizer is phase-locked to an already operating external standard, such as the Type 1115-B Standard-Frequency Oscillator, it is necessary to allow complete equipment warm-up to a steady-state condition, if the ultimate in stability is required. Very small frequency errors due to phase drifts of tuned circuits in the synthesizer can be important in some demanding applications.

For extremely precise work, a warm-up period of two hours or more is recommended. In fact, round-the-clock operation is desirable when feasible, if high precision is apt to be required on short notice. To conserve the dial light bulbs during standby periods, depress the left-most disable button and set the CAD mode switch to EXTERNAL CONTROL.

3.3 CONTINUOUSLY ADJUSTABLE DECADE CONTROL.

3.3.1 GENERAL.

To make use of the Continuously Adjustable Decade (CAD) to control the output frequency, and to maintain a continuous or intermittent monitor of the CAD, observe the operating instructions permanently displayed on a front-panel instruction plate, which are as follows:

> Pushbuttons select functional position of CAD (continuously adjustable decade).
> CAD dial replaces the digit at actuated button and all digits to the right.
> To compare CAD with replaced digits use MONITOR at CAD CAL or observe frequency at BEAT (10 kc/s per major CAD division).

This condensed instruction reminds the user of the following points:

1. If any of the gray pushbuttons is depressed (and thereby automatically latched), the digit displayed on the dial directly above the actuated button and all the digits to the right are disabled, with regard to their effects on the output frequency, and replaced by the CAD unit. If the CAD OFF button is depressed, the CAD is removed from circuit but is still operative and will not be subject to warm-up drift when later reconnected.

2. The replaced digits (which are no longer illuminated by the dial lamps but are still legible) may be used as a reference for adjustment of the CAD. There are two methods of comparison between the CAD and the darkened digits, as described in paragraphs immediately following. Refer also to paragraphs 4.4 through 4.6 for a more detailed discussion of the principles involved.

The output frequency of the "replaced" group of DI-1 units, between 5 and 5.1 Mc/s, is also available at the subminiature coaxial connector marked 5/5.1 REFERENCE on the rear edge of the chassis deck.*

3.3.2 INTERNAL CAD MONITOR.

With the MONITOR switch in the CAD CAL position, the MONITOR meter will read upscale (right from center), if the CAD is far removed in frequency from the replaced digits. As the CAD is tuned either manually or electrically (refer to paragraph 3.3.5) to approach equality with the replaced digits, the pointer will move toward center scale and, as equality is nearly achieved, the pointer will follow the beat frequency between the CAD signal and the signal from the replaced digit-unit group. If the beat frequency is low enough to be visible as a fluttering of the pointer, the CAD has been set accurately enough to replace at least three of the darkened digit dials correctly.

3.3.3 EXTERNAL CAD MONITOR.

Regardless of the position of the MONITOR switch, a signal appears at the BEAT binding posts which is directly proportional in frequency to the difference between the CAD output and that of the digit group which it has replaced. The Type 1142-A Frequency Meter is recommended for observation of signals present at these terminals when a deliberate offset is desired between the CAD and the replaced digits. As shown on the front-panel instruction plate, this frequency difference appears at the rate of 10 kc/s per major (numbered) CAD division. This means that if the CAD has been set to replace the digits displayed on the darkened dials exactly, the signal at the BEAT terminals is at zero frequency. If the CAD is changed in tuning by an amount corresponding to one major division on its dial, or if the dial directly above the actuated button is changed by one number (from 4 to 3 or from 4 to 5, for example), the signal at the BEAT terminals will change by 10 kc/s. Smaller or larger tuning changes produce correspondingly smaller or larger proportional changes in the frequency at BEAT. Similarly, a change of one number of the digit dials immediately to the right of the actuated button, or a change of one minor division of the CAD dial, will result in a 1-kc signal change at the BEAT terminals, etc. Whenever the CAD is being used with either manual or electrical control for frequency sweep or search, this signal at the BEAT terminals may be used as a magnified measure of the departure of the output frequency from that displayed on the whole series of frequency dials.†

3.3.4 ADDITIONAL PRECISION DIGITS FROM CAD.

Paragraphs 3.3.1 through 3.3.3 show how the CAD can easily be set to precise equality with up to 4 digit dials. This feature makes it possible to generate a frequency known to several more significant figures than would be possible using only the stepped digit dials and the CAD dial markings. This capability is of most use in a stripped-down instrument, such as a Type 1162-A4C, although complete instruments sometimes can usefully employ this technique.

> EXAMPLE: To set an output frequency of 953,241.72 c/s from a Type 1162-A4C synthesizer (which has only four digit dials), proceed as follows:
>
> a. Set the four digit dials to 4172.
>
> b. Push the button under the first (left-most) digit unit and, with the MONITOR switch in the CAD CAL position, adjust the CAD dial in the neighborhood of 4.172 until visible low-frequency beats occur on the MONITOR meter. (If these beats are slower than 5 c/s, the setting is good to the full four figures.)
>
> c. Now push the button under the CAD unit itself and reset the four digit dials to 9532. The output frequency from the synthesizer is now 953,241.72 c/s, the first four digits being defined by the step dials and the last four by the CAD.

Frequencies set up in this way can usually be relied on through the final figure over a period of several minutes, provided the CAD mode switch is in the INTERNAL LOCK position, where random drifts of the CAD are minimized. The CAD stability can be estimated, in any given situation, by observation of changes in the beat note on the MONITOR meter while controls are set for comparison with the digits as in step b above. If this beat is observed to remain below 10 c/s over a period of time, the uncertainty in the fourth figure of the CAD contribution during this period is no greater than one unit (uncertainty of 0.01 c/s in the numerical example above).

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*Not installed in some early production models.

† "Coherent Decade Frequency Synthesizers," *General Radio Experimenter*, Vol 38 No 9, September 1964, pp 11 and 13.

3.3.5 CAD MODE SELECTION.

The CAD can operate in either of two modes, as selected by the lever switch coaxial with its dial. In the INTERNAL LOCK position of this switch, the CAD is in a highly stable configuration; in this mode its frequency can be changed only by manual control of its knob. In the EXTERNAL CONTROL switch position, the CAD is somewhat less stable with regard to ambient-temperature effects upon it, but it can now be tuned electrically by a signal impressed on the EXTERNAL CAD CONTROL binding posts, as well as by the knob. The dial lighting of the CAD is dimmed in the EXTERNAL CONTROL position of the switch.

When the CAD is switched for external control, a signal of 0.3 Vdc applied to the EXTERNAL CAD CONTROL binding posts will change the CAD frequency by an amount approximately equal to one major division of its dial, from a starting point as indicated by its dial setting. Positive control voltage decreases the CAD frequency, and vice versa. This relationship is recorded on the panel, adjacent to the EXTERNAL CAD CONTROL binding posts, for easy reference. The CAD can be controlled electrically up to ±5 divisions (or more) about any center frequency at which its dial is set.

3.4 OUTPUT ADJUSTMENTS.

The remaining panel controls for routine operation consist of the OUTPUT LEVEL control and the OUTPUT COUPLING* screwdriver-operated switch, which changes the normal ac-coupled output-amplifier circuits to direct coupling. Dc coupling is used only when very low output frequencies are required. In the AC position of the OUTPUT COUPLING switch, the MONITOR switch in its OUTPUT VOLTS position connects the meter to read from 0 to 2 V rms at the output connector. In the DC position the monitor meter is no longer connected, but 0.8 volt rms is available at the OUTPUT connector at frequencies as low as desired, down to dc. The OUTPUT LEVEL control still functions, but the source impedance is generally high and is variable with setting, up to about 4 kilohms.

3.5 OPERATION WITH EXTERNAL STANDARD.

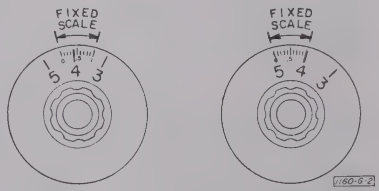
The fully clockwise position of the MONITOR switch, marked LOCK TO EXT STD, is of use only in applications where the stability of the internal crystal standard is not adequate and a signal from a more stable standard, such as the General Radio Type 1115-B Standard-Frequency Oscillator, has been connected to the LOCK SIG IN connector at the rear of the instrument. If such a signal (0.2 V rms or more, at 5 Mc/s or at a submultiple of 5 Mc/s down to 100 kc/s) has been supplied, and if the MONITOR switch is in the LOCK TO EXT STD position, the meter indicates the error voltage generated in a phase detector which disciplines the internal crystal oscillator to conform in frequency with the external standard. To check for proper operation of this phase lock, rotate the screw-driver control marked CRYSTAL FREQ and confirm that the meter follows this control smoothly from one side of center, through center, and over to the other side. The CRYSTAL FREQ control should be left so that the meter is centered, although phase lock will still obtain at any other meter indication that is still under control of the screw-driver adjustment.

3.6 CRYSTAL-OSCILLATOR ADJUSTMENT.

The CRYSTAL FREQ control can also be used as a vernier control on the frequency of the internal master oscillator, if an external locking signal is not connected. In such a case, some reference (such as a counter or other frequency meter, or a Lissajous pattern obtained with a known stable frequency on an oscilloscope) may be used. A signal sample can be taken from either of the two GR874 connectors at the rear of the instrument, on the AFS unit, marked 100 KC OUT or 5 MC OUT, or from the main output receptacle on the front panel, at whatever frequency has been dialed.

3.7 CAD DIAL INTERPRETATION.

The CAD dial displays its setting in a fashion designed to eliminate any chance for misreading. Like all the other frequency controls, the CAD knob increases output frequency with clockwise rotation. The dial carries a series of numbered fiducial lines, each of which is read against the fixed, fine-scale, illuminated sector. Figure 3-1 illustrates the principle.



READING IS 4.40

READING IS 4+1=5.0
OR 5+0=5.0

Figure 3-1. Representative readings of Continuously Adjustable Decade (CAD) dial.

3.8 SYSTEM SELF-CHECK.

Warning circuitry extinguishes the dial lamp of a malfunctioning Digit Insertion unit. In addition, the design provides for a very easy routine check for proper frequency generation. Details are covered in paragraph 5.3.

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*In the Type 1163-A this control is marked OUTPUT IMPEDANCE, and determines whether a 50-ohm resistor is or is not connected in series with the output. The meter reads voltage delivered from a 5-ohm (approximate) source impedance at the input side of this 50-ohm resistor. In the ZERO position of the control the meter is directly across the output.

3.9 OPERATION OF SYSTEMS NOT FULLY EQUIPPED.

The design of the synthesizers permits operation with less than the full complement of digit units. The CAD can also be omitted for some applications. However, inclusion of the CAD is recommended in any but the most specialized systems. It provides very useful general-purpose features.

All the operational features discussed above (refer to paragraphs 3.1 to 3.8) apply to any of the partially equipped units, if one remembers that:

1. The CAD dial reading follows directly the last installed digit dial (when the CAD is in circuit as a result of pushing B_8, Figure 5-1).

2. All buttons under stations where digit units have not been installed act just the same as B_8—if any of them is depressed, the CAD is contributing to the output frequency and its dial reading follows immediately after the last installed dial.

3. It is important that a DI-1 Bridging Unit (part number 1160-4070) be installed in each Digit Insertion unit station not otherwise filled. (These are installed at the factory as components of partially equipped models).

NOTE

A spare DI-1 Bridging Unit is supplied with each synthesizer. If for any reason one of the originally installed digit units must be removed, its place should be filled by a digit unit taken from the right-hand end of the group of installed units and the bridging unit should be used to fill the resulting gap. (A bridging unit may be installed at any DI-1 station. But, unless the installed digit units are continuous, starting at the left-hand end of the chassis, the dial strip will not indicate frequency step size correctly.)

4. If the CAD unit is omitted, a CAD Bridging Unit (part number 1160-4080) should take its place. If this is done, all pushbuttons to the right of the one under the last installed digit unit are ineffective and may be depressed with no penalty.

NOTE

If the CAD Bridging Unit is not installed, it is necessary to see to it that the CAD OFF button is always depressed, otherwise the instrument will not generate proper frequencies.

5. If the CAD is omitted, none of the self-checks (paragraph 3.8) can be performed, although a partial check can still be made, without additional equipment, by setup of a 1- or 2-cycle output frequency, as noted in paragraph 5.6.5.

SECTION 4

PRINCIPLES OF OPERATION

4.1 GENERAL.

The Types 1161-A, 1162-A, and 1163-A Coherent Decade Frequency Synthesizers are so nearly identical that, except as noted, the principles of operation are the same for each. Treatment here is restricted to the system level.

4.2 DIFFERENCES BETWEEN SYSTEMS.

All three equipments are fundamentally beat-frequency oscillators. In each, a fixed frequency is subtracted (in an output mixer) from an adjustable frequency, and the resulting difference-frequency signal, suitably amplified, is the final output. (In the

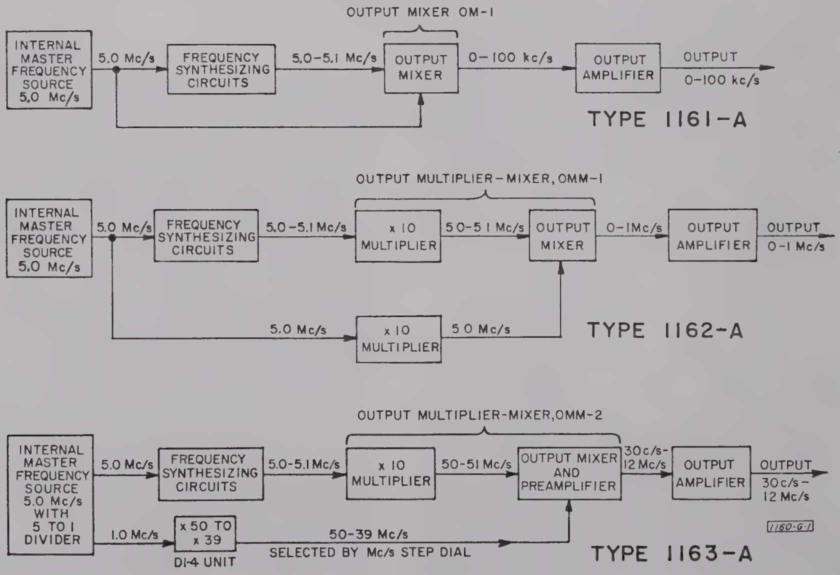

OUTPUT MIXER OM-1
INTERNAL MASTER FREQUENCY SOURCE 5.0 Mc/s
5.0 Mc/s
FREQUENCY SYNTHESIZING CIRCUITS
5.0–5.1 Mc/s
OUTPUT MIXER
0–100 kc/s
OUTPUT AMPLIFIER
OUTPUT 0–100 kc/s
TYPE 1161–A
OUTPUT MULTIPLIER–MIXER, OMM–1
INTERNAL MASTER FREQUENCY SOURCE 5.0 Mc/s
5.0 Mc/s
FREQUENCY SYNTHESIZING CIRCUITS
5.0–5.1 Mc/s
x 10 MULTIPLIER
50–51 Mc/s
OUTPUT MIXER
0–1 Mc/s
OUTPUT AMPLIFIER
OUTPUT 0–1 Mc/s
5.0 Mc/s
x 10 MULTIPLIER
50 Mc/s
TYPE 1162–A
OUTPUT MULTIPLIER-MIXER, OMM-2
INTERNAL MASTER FREQUENCY SOURCE 5.0 Mc/s WITH 5 TO 1 DIVIDER
5.0 Mc/s
FREQUENCY SYNTHESIZING CIRCUITS
5.0-5.1 Mc/s
x 10 MULTIPLIER
50-51 Mc/s
OUTPUT MIXER AND PREAMPLIFIER
30 c/s–12 Mc/s
OUTPUT AMPLIFIER
OUTPUT 30 c/s – 12 Mc/s
1.0 Mc/s
x 50 TO x 39
DI-4 UNIT
50-39 Mc/s
SELECTED BY Mc/s STEP DIAL
1160-G-1
TYPE 1163–A

Figure 4-1. Elementary functional diagram of synthesizer circuitry.

Type 1163-A, the "fixed" frequency is itself adjustable, in 1-Mc steps, by the left-hand frequency dial).

In the Type 1161-A synthesizer, 5.0 Mc/s is subtracted from a dial-selected frequency ranging from 5.0 to 5.1 Mc/s. In the Type 1162-A synthesizer, 50.0 Mc/s is subtracted from a frequency lying between 50 and 51 Mc/s to produce the output. In the Type 1163-A, a 1-Mc signal between 50 and 39 Mc/s is subtracted from the synthesized frequency lying between 50 and 51 Mc/s. These relationships are shown in the basic block diagrams of Figure 4-1. As can be seen, the major differences between systems is in the use of the Output Mixer, OM-1, module in the Type 1161-A, use of the Output Multiplier-Mixer, OMM-1 in the Type 1162-A, and in Type 1163-A the use of a slightly different Main Frame chassis, with the megacycle-selector unit, DI-4, and the OMM-2 Output Multiplier-Mixer installed. In the Types 1161-A and 1162-A, the Output Mixer modules are of identical physical size and can be plugged into the (1160-4060) Main Frame, thus transforming one type of instrument into the other. (A corresponding dial-strip change is also necessary.) As noted, the Type 1163-A uses a different Main Frame (1163-4060).

The remaining modules of either the Type 1161-A or 1162-A are as follows:

Ancillary Frequency Source
Frequency synthesizing circuits, comprising:
  Digit-Insertion units, Type DI-1 or RDI-1
  (3 to 7 may be installed)
  Continuously Adjustable Decade

Calibrating Mixer
Power Supply

In the Type 1163-A the Main Frame is slightly different, and a special module — the DI-4 — occupies the left-hand digit position.

These modules will be briefly described before the general synthesizing principle is discussed. The modules appear in Figure 4-2 and a top view of the Main Frame is shown in Figure 4-3.

NOTE

Detailed descriptions of each of the plug-in modules, and of each of the Main Frames, are contained in separate sections included in this book under headings appropriate to the unit in question.

4.3 MODULAR COMPONENTS.

4.3.1 GENERAL.

The DI-1, CAD, AFS, CM-1, and PS-1 are used in all three synthesizers and will be described first. The Output Mixer OM-1 is unique to the Type 1161-A and is replaced, in the Type 1162-A, by the OMM-1. The DI-4 and the OMM-2 are used only in the Type 1163-A, which, as noted above, also has a slightly different chassis.

4.3.2 DIGIT-INSERTION UNIT — TYPE 1160-DI-1.

This module, basic to all the frequency-synthesizer assemblies in this series, is used repetitively to provide selection of each available digit. A DI-1 unit is plugged in behind each of the digit dials.

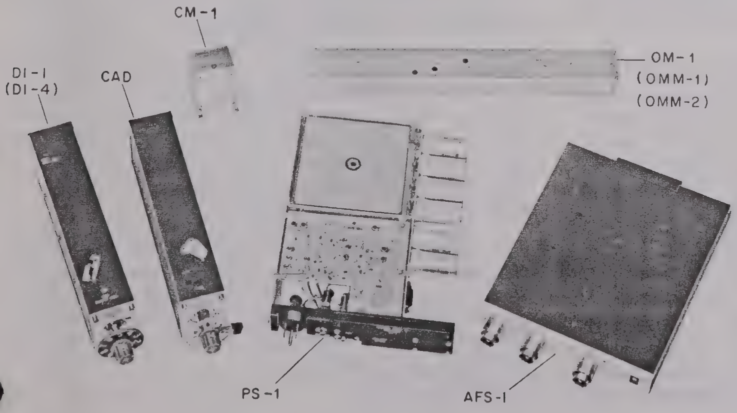
The RDI-1 unit is very similar and can be mounted interchangeably with the DI-1 in any digit-unit station. It provides ten local-control digit-selection positions on its dial, plus an "R" position which transfers control to a connector at the rear of the RDI-1 unit itself.

4.3.3 CONTINUOUSLY ADJUSTABLE DECADE — TYPE 1160-CAD.

This unit provides continuous frequency coverage on a single dial over wide or narrow frequency regions as selected by pushbuttons. It may be omitted if continuous coverage is not required, although it is valuable for system self-checks (refer to paragraph 3.8). It is used in all synthesizers.

4.3.4 ANCILLARY FREQUENCY SOURCE — AFS-1.

In this module is the 5-Mc/s master crystal oscillator from which all frequencies used in the synthesis are derived. It furnishes an output at 42 Mc/s, which is fed to all the DI-1 units and to the CAD. It also generates a "picket fence" of frequencies spaced



LEGEND

DI-1	Digit-Insertion Unit
DI-4	Digit-Insertion Unit (Type 1163 only)
CAD	Continuously Adjustable Decade
CM-1	Calibrating Mixer
PS-1	Power Supply
OM-1	Output Mixer (Type 1161)
OMM-1	Output Multiplier-Mixer (Type 1162)
OMM-2	Output Multiplier-Mixer (Type 1163)
AFS	Ancillary Frequency Source

Figure 4-2. Basic synthesizer modules. Dial-light panels for a Digit unit and the CAD are shown on top of their respective modules.

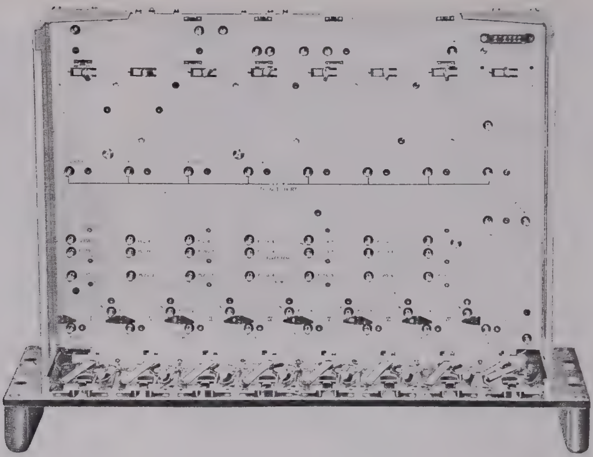


Figure 4-3. Top view of synthesizer Main Frame chassis used for Type 1161-A and 1162-A (refer to Section BA). The Main Frame for the Type 1163-A is nearly the same (refer to Section BB).

100 kc/s apart between 3 and 3.9 Mc/s. This picket fence is used in each DI-1 unit for digit-selection purposes. It also supplies 1.0 Mc/s to the DI-4 unit in the Type 1163-A.

4.3.5 CALIBRATING MIXER — CM-1.

This simple module compares the output frequency of the CAD unit with the dialed output frequency of any chosen group of DI-1 units for self-calibration or marker generation. If the CAD unit is not installed in a system, this mixer is omitted also.

4.3.6 OUTPUT MIXER, OM-1, AND OUTPUT MULTIPLIER-MIXER, OMM-1.

These modules, mechanically interchangeable, provide frequency translation between the synthesizing modules and the output circuits of the Types 1161-A and 1162-A synthesizers, respectively. Replacement of one by the other in the (1160-4060) Main Frame changes the instrument from a Type 1161-A to a Type 1162-A, or vice versa.

4.3.7 POWER SUPPLY — PS-1.

This unit accepts ac power from the line or dc from a 20- to 28-V battery and supplies 18 V, regulated, to operate the synthesizer.

4.3.8 DIGIT-INSERTION UNIT — TYPE 1163-DI-4.

The DI-4 unit, which supplies digit steps of 1 Mc/s, is mounted on the 1163-4060 chassis in the left-hand digit station. Its only signal input is one of 1.0 Mc/s, taken from the AFS unit. Its output is one of 12 frequencies (from 50 to 39 Mc/s) that are beat with a signal (between 50 and 51 Mc/s) synthesized by the DI-1 units. The DI-4 unit has the same form factor as the DI-1 and bears a dial marked from 0 to 11 that reads 1-Mc steps in the final output frequency.

4.3.9 OUTPUT MULTIPLIER-MIXER 1163-OMM-2.

This module, which is of the same size and shape as the OM-1 and OMM-1 of the Type 1161/1162 synthesizers, plugs into the top rear of the chassis of the Type 1163-A. It combines the output frequency of the train of DI-1 units to produce the final output frequency of the synthesizer. It also includes a preamplifier for the output-frequency signal generated in the low-level mixer of this unit.

4.3.10 MAIN FRAME.

Figure 4-3 shows the Main Frame into which the above listed modules are plugged to make up either a Type 1161-A or a Type 1162-A synthesizer. Its deck is of "sandwich" construction, with banana plugs protruding downward to engage the power supply and the AFS, and upward to connect with all other modules. It contains the pushbutton switches that control the functional position of the CAD, the monitoring circuits, and the final-output amplifier. The Main Frame for the Type 1163-A is nearly identical.

4.4 THE SYNTHESIZING PRINCIPLE.

The discussion which follows is based on the Types 1161-A and 1162-A. The Type 1163-A utilizes all the principles described here, with some additions which are covered separately in paragraph 4.7.

The blocks in Figure 4-1 labeled "Frequency Synthesizing Circuits" comprise, in a complete instrument, a train of eight units of the same outside dimensions (seven DI-1 units and a CAD). In the synthesizing process, the signal starts at the right-hand end of the train (at the CAD unit) and proceeds toward the left through seven* identical Digit Insertion units in sequence, being slightly modified in accordance with the dialed digit information as it passes through each unit. The frequency level, through this whole section, is always between 5.0 and 5.1 Mc/s.

Each DI-1 module in the synthesizer receives an input signal at about 5 Mc/s, modifies the frequency of this signal very slightly in two steps, and delivers the modified frequency (again near 5 Mc/s) as an input to the next DI-1 unit in the train. Figure 4-4 is an elementary diagram showing the essential processes performed in a DI-1 unit.

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*Six, in the Type 1163-A.

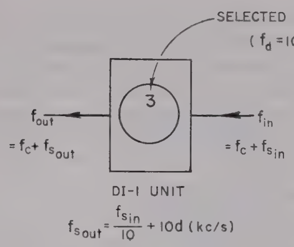

Figure 4-4. Signal traversing a typical DI-1 Digit-Insertion unit.

In Figure 4-4 each signal (input and output) is shown as having a frequency that, for convenience, may be regarded as the sum of two components. The first component is a "carrier" frequency, which remains unchanged through all the DI-1 units at 5000 kc/s.

The second component is the "signal" component. The signal component always lies between 0 and 100 kc/s.

The signal component is modified by passage through each Digit-Insertion unit in the following very simple ways, as indicated in the figure. If we denote the total input frequency by

$$f_{in} = f_c + f_{s_{in}} \quad \text{kc/s} \qquad (4\text{-}1)$$

and the output frequency by

$$f_{out} = f_c + f_{s_{out}} \quad \text{kc/s} \qquad (4\text{-}2)$$

then the DI-1 unit performs operations so that:

$$f_{out} = f_c + \frac{f_{s_{in}}}{10} + 10\,d \text{ kc/s} \qquad (4\text{-}3)$$

or

$$f_{s_{out}} = \frac{f_{s_{in}}}{10} + 10\,d \quad \text{kc/s} \qquad (4\text{-}4)$$

where

f_{in}, f_{out} = total input and output frequencies

f_c = carrier component, invariant

$f_{s_{in}}$ = signal component of input

$f_{s_{out}}$ = signal component of output

d = selected digit, from 0 to 9 in integral steps.

For convenience in following frequency changes through the train of digit units, we can disregard the carrier component, since this passes through unchanged, and concentrate on only the signal component, as in Equation (4-4).

Figure 4-5 shows four DI-1 units (A, B, C, D), each with digits selected as indicated, and the signal-component flow through the train, from right to left. Observe the correspondence between the signal component of output frequency from unit A (24.39 kc/s) and the digit dial settings (2439). The output frequency from any unit in such a train of digit units will have a signal component that is, in kilocycles per second:

$$f_s = 10d_1 + d_2 + 0.1\,d_3 + 0.01\,d_4 + \ldots \qquad (4\text{-}5)$$

where d_1 represents the dialed digit on the unit at which the output frequency is measured, and d_2 through d_n represent digits dialed on successive units to the right.

Equation (4-4) defines the two fundamental operations performed on the signal component by each digit unit, which permit frequency synthesis in steps as small as may be desired. These operations are:

1. Divide the input signal component by 10.
2. Add to this a digit component that is 10 times the dialed digit (in kc/s), and pass the result on to the input of the next DI-1 unit in the train.

4.5 CAD SWITCHING AND SELF CALIBRATION.

Behind each pushbutton on the panel is an rf switch which controls the functional position of the CAD and also arranges for the self-calibration feature. The simplified block diagrams of Figure 4-6 and 4-7 illustrate the principle; for more detailed information, see the separate sections on the Main Frames. The actual switching is a little more complex than shown in Figures 4-6 and 4-7, due to the necessity for shielding, but the signal paths are the same.

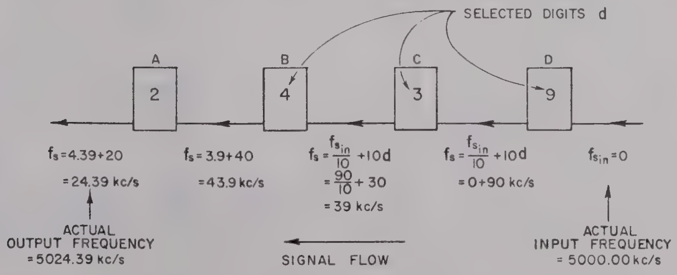
SELECTED DIGITS d
A
B
C
D
2
4
3
9
f_s=4.39+20
=24.39 kc/s
f_s= 3.9+40
=43.9 kc/s
$f_s = \frac{f_{s_{in}}}{10} + 10d$
$= \frac{90}{10} + 30$
= 39 kc/s
$f_s = \frac{f_{s_{in}}}{10} + 10d$
= 0+90 kc/s
$f_{s_{in}}$=0
ACTUAL OUTPUT FREQUENCY =5024.39 kc/s
SIGNAL FLOW
ACTUAL INPUT FREQUENCY = 5000.00 kc/s

Figure 4-5. Signal flow through four Digit-Insertion units shown to illustrate synthesis of desired signal component.

Figure 4-6 shows seven DI-1 units with dials set as indicated by the numbers in the boxes at the top. The resulting "signal components" (refer to Equation 4-4) of frequency passing between them appear below the boxes. The CAD unit, although present, is disconnected from the train because the CAD OFF button unlatches all other buttons, so that the switches are positioned as shown in Figure 4-6.

Figure 4-7 is the same except that B_5 has now been depressed, so that the CAD is operative and its output becomes the input to digit unit number 4.

With reference to Figures 4-6 and 4-7, observe that:

1. The output frequency is the same in each, though in Figure 4-6 seven digit units are working and the CAD is idle, while in Figure 4-7 four digit units and the CAD cooperate to produce the output frequency.

2. The beat-frequency output from the Calibrating Mixer is 0 in Figure 4-7, indicating that the CAD has correctly replaced digit units numbers 5, 6, and 7.

Consider now what would have been the result in Figure 4-7 if the CAD dial had been set to 6.13 instead of 5.13 as shown. First, the signal components would have been modified as indicated in the first five lines of Table 4-1.

Second, the synthesizer output frequency would have been increased by 1.00 c/s (if Type 1161-A), or by 10.0 c/s (if Type 1162-A), and third, the beat frequency available at the BEAT binding posts would have changed from 0 to 10 kc/s, as shown at the bottom of the table.

If button B_6 is pushed instead of B_5, a change of one major division of the CAD will still produce a 10-kc/s change at BEAT, but the effect on the output frequency in the Type 1161-A is only 0.1 c/s.

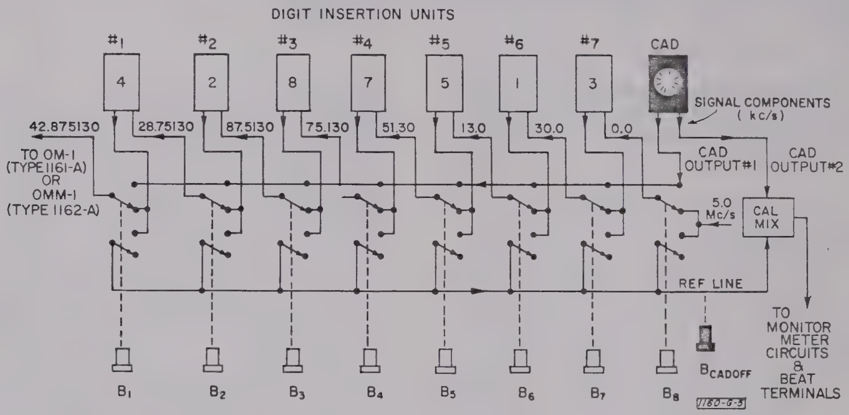
DIGIT INSERTION UNITS
#1
#2
#3
#4
#5
#6
#7
CAD
4
2
8
7
5
1
3
SIGNAL COMPONENTS (kc/s)
42.875130
28.75130
87.5130
75.130
51.30
13.0
30.0
0.0
TO OM-1 (TYPE 1161-A) OR OMM-1 (TYPE 1162-A)
CAD OUTPUT#1
CAD OUTPUT#2
5.0 Mc/s
CAL MIX
REF LINE
TO MONITOR METER CIRCUITS & BEAT TERMINALS
B1
B2
B3
B4
B5
B6
B7
B8
BCADOFF
1160-G-5

Figure 4-6. Example of synthesis achieved by seven Digit-Insertion units. Pushbutton $B_{CAD\ OFF}$ has been actuated so that CAD is not contributing to the output.

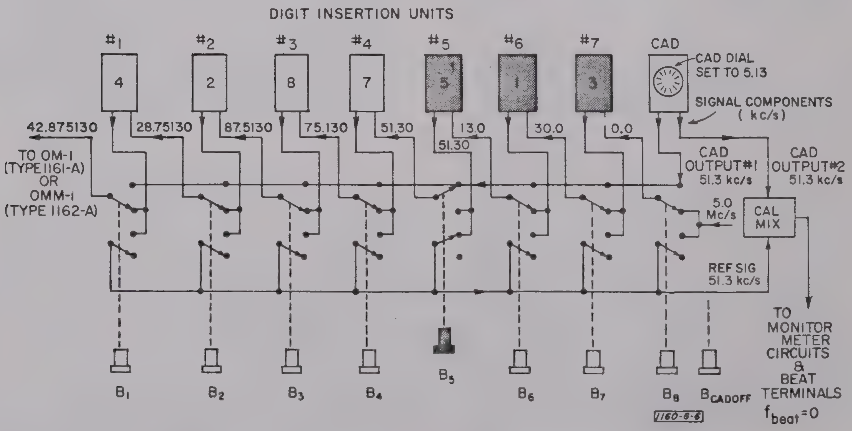
DIGIT INSERTION UNITS
#1
#2
#3
#4
#5
#6
#7
CAD
CAD DIAL SET TO 5.13
4
2
8
7
5
1
3
SIGNAL COMPONENTS (kc/s)
42.875130
28.75130
87.5130
75.130
51.30
13.0
51.30
30.0
0.0
TO OM-1 (TYPE 1161-A) OR OMM-1 (TYPE 1162-A)
CAD OUTPUT#1 51.3 kc/s
CAD OUTPUT#2 51.3 kc/s
5.0 Mc/s
CAL MIX
REF SIG 51.3 kc/s
TO MONITOR METER CIRCUITS & BEAT TERMINALS
f beat=0
B1
B2
B3
B4
B5
B6
B7
B8
BCADOFF
1160-G-6

Figure 4-7. Example of synthesis by four Digit-Insertion units and the CAD. Pushbutton B_5 has been actuated so that the input to digit unit 4 comes from CAD. The output of the digit unit 5 is compared with the CAD output in the Calibrating Mixer. As shown, zero beat is achieved.

TABLE 4-1
EFFECT OF CAD ON SYNTHESIZER READOUT

Signal Components	*CAD at 5.13 as in Figure 4-7*	*CAD at 6.13*
Input to digit unit 4	51.3 kc/s	61.3 kc/s
Input to digit unit 3	75.13 kc/s	76.13 kc/s
Input to digit unit 2	87.513 kc/s	87.613 kc/s
Input to digit unit 1	28.7513 kc/s	28.7613 kc/s
Output of digit unit 1	42.87513 kc/s	42.87613 kc/s
Synthesizer Output (if Type 1161-A)	42,875.13 c/s	42,876.13 c/s (change = 1.0 c/s)
Synthesizer Output (if Type 1162-A)	428, 751.3 c/s	428,761.3 c/s (change = 10.0 c/s)
Output at BEAT terminals (in either synthesizer)	0	10 kc/s

Or, if button B_3 is depressed, one major division change of the CAD will change the output frequency by 100 c/s in the Type 1161-A or by 1 kc/s in the Type 1162-A. In either event, the change at BEAT is still 10 kc/s.

4.6 DIAL LIGHTING.

Behind each dial is a white plastic plug-in assembly which contains a lamp bulb. In normal operation, each of these lamps is turned on whenever the corresponding digit unit (or CAD) is contributing to the output frequency.

A second set of switches, operated by the pushbuttons (but not shown in Figures 4-6 and 4-7), serves to turn off all digit-dial lights above and to the right of any actuated button, and to turn on the CAD dial lamp. Figure 4-8 shows the wiring of these switches, and also the set of transistors, mounted on the lamp-switching cards behind the front panel, which sense malfunction of phase lock in a digit unit and extinguish the corresponding dial light to give warning.

Pushbuttons B_1 through B_7 operate the lamp switches of Figure 4-8 and also the rf switches of Figures 4-6 and 4-7. B_8 operates only an rf switch, and $B_{CAD\ OFF}$ controls only a lamp switch, as shown. When $B_{CAD\ OFF}$ is actuated, the CAD lamp is off and all other lamps are on; whenever any other button is depressed, the CAD dial is illuminated.

NOTE

Each button, when actuated, latches in the depressed position and at the same time releases all other buttons to normal position.

Figure 4-8 shows seven error-sensing probes, each of which makes contact to a pin protruding through the front panel of the Digit Insertion unit installed behind the corresponding dial lamp. Each of these pins is normally at a positive potential with respect to ground. Hence, the transistors shown in Figure 4-8 are all turned on, and each lamp circuit to ground is complete. Lamps corresponding to button B_5 (which is depressed) and to B_6 and B_7 are extinguished by the opening of the switch at B_5, which disconnects the voltage source from these lamps.

In the event of a phase-lock malfunction in a DI unit, however, the probe in the digit unit at fault will be at ground potential. The corresponding transistor is turned off and the lamp extinguished. (For details of the error-sensing circuits, see the separate sections of this book on the Digit-Insertion units.)

An additional switch, ganged with the EXT CONTROL-INTERNAL LOCK switch, is shown at the right of Figure 4-8. As indicated, this inserts a resistor in series with the CAD dial lamp, when the CAD mode switch is in the EXTERNAL CONTROL position, to dim the lamp.

4.7 TYPE 1163-A – IDENTITIES AND DIFFERENCES.

The only important difference between the Type 1163-A and its two lower-frequency counterparts is in the signals fed to its output mixer, to generate the final output-frequency band. In what follows, familiarity with the material of paragraphs 4.1-4.6 is assumed.

In the Type 1163-A, the output mixer is fed, on one side, by a synthesized frequency between 50 and 51 Mc/s, produced exactly as in the Type 1162-A, by multiplication by ten of the output frequency of a train of DI-1 units (see Figure 4-1).

The other side of the output mixer is supplied by one of twelve frequencies, selected by the dial of the DI-4 unit, which lie between 50 and 39 Mc/s at 1-Mc intervals. The DI-4 unit occupies the left-hand digit-unit station on the Main Frame, in a location corresponding to the highest-rank digit unit in the Type 1161 or 1162. Since the input and output signals of the DI-4 are different from those of a DI-1, the chassis wiring of the Type 1163-A is different in this region.

The DI-4 unit takes 1.0 Mc/s as its only signal input, and, by sampling-phase-detector and locked-oscillator techniques, develops an output at 50 Mc/s when its dial is set at 0, 49 Mc/s at a dial setting of 1, and so on, to an output of 39 Mc/s at 11 on its dial.

This output signal is fed by wiring in the sandwich deck to the output mixer in the Output Multiplier-Mixer Unit, OMM-2.

Since the CAD can never functionally replace the DI-4, the pushbutton under this unit is not installed in the 1163-4060 chassis.

Otherwise, the operation of the pushbuttons and of the CAD is exactly as in the Types 1161-A and 1162-A, described in detail earlier. Figures 4-6, 4-7, and 4-8 are adequate for an understanding of the principles involved, if one bears in mind that the #1 digit-unit station is occupied by a DI-4 Unit, which supplies 1-Mc spaced frequencies to the OMM-2. Pushbutton B$_1$ and its associated switching are omitted, and the output to the other side of the OMM-2 is taken, via the switch associated with button B$_2$, from the last (sixth) DI-1 Unit, in station #2.

The Output Multiplier-Mixer OMM-2 has the same dimensions as the OM-1 or the OMM-1 and occupies a corresponding position on the chassis. About half is occupied by circuits identical with those in the OMM-1 for multiplication of 5/5.1 to 50/51 Mc/s. The other half contains the mixer and a preamplifier that raises the output of this low-level mixer to a level suitable for input to the Output Amplifier, mounted behind the bottom of the front panel.

The Output Amplifier is very similar to that used in the 1160-4060 chassis but has greater bandwidth, on account of the 12-Mc top frequency.

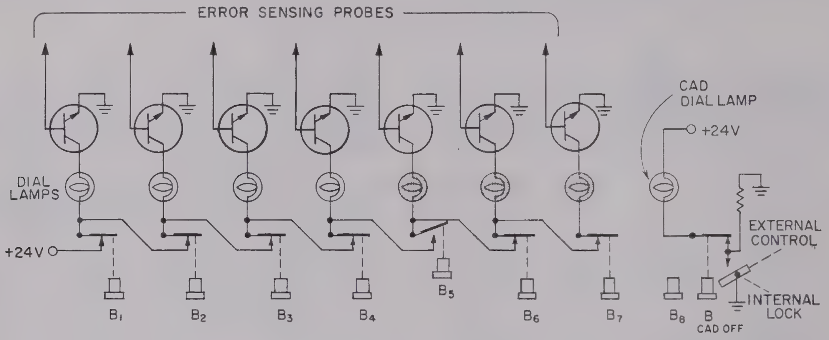

Figure 4-8. Dial-lamp switching circuits with B$_5$ actuated; lamps 5, 6 and 7 are off, CAD lamp is on. See also Figures 4-6 and 4-7 for rf switching, also controlled by pushbuttons B$_1$ through B$_8$. This figure plus Figures 4-6 and 4-7 is illustrative of either a Type 1161-A or Type 1162-A synthesizer. In a Type 1163-A, pushbutton B$_1$ and its associated switching are omitted, and station #1 is occupied by a DI-4 Unit. Refer to sub-sections BA and BB on the Main Frame.

SECTION 5

SERVICE AND MAINTENANCE

5.1 WARRANTY.

General Radio warrants that each new instrument sold direct is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, district office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

The two-year warranty stated above attests the quality of materials and workmanship in General Radio products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our nearest Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

NOTE

> Each interchangeable plug-in module carries its own individual serial number, and the serial number on the front panel of the synthesizer applies only to the Main Frame.

Before returning an instrument to General Radio for service, please write to the Service Department or nearest district office, requesting a "Returned Material Tag." Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.2 SERVICE INSTRUCTIONS.

This section is devoted to a description of the mounting arrangements for the various plug-in modules and to suggestions for methods of localizing trouble to a particular module, if any system malfunction is discovered. Refer to paragraph 5.3 for system self-check procedures. Most of the following is written in terms of the Types 1161-A/1162-A synthesizers. Applications to the Type 1163-A should be obvious, since all units are so nearly identical. For more details on the differences, refer also to Sections BA and BB, on the Main Frames, and the sections on the modules.

If improper frequency generation in a Type 1163-A is suspected, refer also to Section DC.

5.3 SYSTEM SELF-CHECK.

5.3.1 GENERAL.

The calibration circuitry permits a very easy check of each digit unit, by the methods discussed below. Refer to the digit dials by number, from D_1 to D_7, and to the pushbuttons by number, from B_1 to B_8 plus $B_{\text{CAD OFF}}$, as indicated in Figure 5-1.

NOTE

> Set the MONITOR switch at CAD CAL, as indicated, and the CAD mode switch in the INTERNAL LOCK position.

5.3.2 LOW-END CHECK (ZEROS).

To check the low-end ("0" digit) frequency of all installed DI-1 Digit-Insertion units, proceed as follows:

a. Set all digit dials to zero, and actuate B_8, under the CAD unit.

b. Adjust the CAD dial to (or close to) 0.000 to achieve a visible low-frequency oscillation of the needle of the MONITOR meter.

NOTE

> By this process, the actual output frequency of the CAD has been set to 5.0 Mc/s, exactly corresponding to digit "0". (The error, at 5 Mc/s, is only the visible beat frequency, which is completely negligible in its effect on the synthesizer output frequency.)

c. Now actuate B_7. (If the instrument is a stripped-down version, with fewer than 7 DI units, actuate the button under the last installed unit.) In a complete instrument the digit dial reading is now 000000$\underline{0}$, (the underline under the last digit indicates that the button under this digit has been depressed). If digit-unit 7 is behaving properly in its "0" position, the beat on the MONITOR meter will be unchanged from that set-up under step a. If the beat disappears, digit-unit 7 is not operating properly and should be serviced. (See detailed section of this book on the DI-1 unit.)

d. Actuate B_6. (Digit dial reading is 00000$\underline{0}$0, with actuated button indicated by underline, as before.) Beat on MONITOR should be unchanged. If it disappears, digit-unit 6 needs service.

e. Continue to actuate buttons progressively toward the left, from reading 0000$\underline{0}$00 through 000$\underline{0}$000 and so on to $\underline{0}$000000, with B_1 actuated.* If all digit units are generating "0's" properly, the beat on the MONITOR meter will be unchanged through this whole sequence. If the low-frequency beat disappears when any button is depressed, the digit unit at that station needs attention. (It may easily be removed for repair, the only penalty being the temporary loss of one digit of resolution. Refer to paragraph 5.5.1 for procedural details.)

5.3.3 HIGH-END CHECK (NINES).

To check the high end ("9" digit) proceed as follows:

a. Set D_1 to 9 (so that the reading is $\underline{9}$000000, with all other digit dials still at 0 and B_1 actuated).†

b. Then, adjust the CAD to (or close to) 9.000 to achieve a low-frequency beat on the MONITOR meter.

c. Depress button B_2 and set D_2 to 9 (reading is now 9$\underline{9}$00000). If both the digit units at D_1 and D_2 are behaving normally, the beat will be unchanged. (If it is not, refer to paragraph 5.3.5.)

d. Continue, in sequence, to set dials to 9 and to depress buttons, from reading 99$\underline{9}$0000 through 999$\underline{9}$000 to 999999$\underline{9}$. If all digit units are normal, the beat on the MONITOR meter will be unchanged through this sequence. If the visible beat disappears at any step, the digit unit at that station probably needs servicing. (Refer to the section of this book on the DI-1 unit.)

5.3.4 SEQUENTIAL CHECK OF OTHER DIGITS.

In general, a check of the end points, at 0 and 9, will give reasonable assurance that the intermediate digits are also functioning properly, but in case of doubt any digit can be confirmed. For instance, set D_1 to 4, depress button B_1, and set the CAD for a visible beat. Then, set D_2 to 4 and depress B_2, for a reading of 4$\underline{4}$00000, and continue (as in paragraphs 5.3.2 and 5.3.3) through readings of 44$\underline{4}$0000 to 444444$\underline{4}$. (Digits 4 and 5, as well as 0 and 9, are logical candidates for this sort of check, since the internal-selection scheme in the DI-1 requires a tracking adjustment between the lower and upper halves of the decade.)

5.3.5 RESOLUTION OF AMBIGUITY.

If step c of paragraph 5.3.3 fails to check, it is possible that the unit at D_1 may itself be in error in the "9" position. In this case the CAD, having been set erroneously to agree with D_1 (which is here assumed to be wrong) will not give a proper check against a correct D_2. On the other hand, D_1 may be right and D_2 wrong. To resolve this ambiguity, compare D_2 with D_3 (reading 9$\underline{9}$00000 compared with 99$\underline{9}$0000) or any other adjacent pair of digit units, to make sure that the CAD has been set to a true reading of 9.000. Once this has been done, the now-verified correct setting of the CAD can be used to discover an error in the unit at D_2 (reading 9$\underline{9}$00000 fails to produce a visible beat). If D_2 is found to be correct and D_1 fails, then the unit at D_1 is in need of service.

5.3.6 CHECK BY DIAL-LIGHT FAILURE.

The procedures of paragraphs 5.3.2 and 5.3.3 will always spot a malfunction at the frequency endpoints of any digit unit, and these checks are quite easy to perform. However, built-in warning circuitry will usually provide a direct and immediate indication

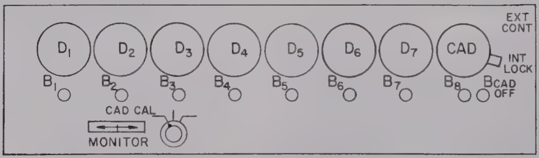

Figure 5-1.
Dial and pushbutton designators for system self-check procedures.

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*In the Type 1163-A, the maximum number of DI-1 units that can be installed is 6 and button B_1 is omitted. To check the operation of the DI-4 unit installed in the last station, consult Section DC.

†In the Type 1163-A, D_1 is on the DI-4 unit, so the starting point of this series of checks is at D_2, with a dial reading of X$\underline{9}$00000. The DI-4 setting, indicated by X, is immaterial.

of such trouble, should it occur. These circuits automatically extinguish the dial lighting for a digit unit in which failure has developed. Refer to paragraph 4.6 and the detailed section of this book on the DI-1 unit. See also the section on the DI-4 unit used in the Type 1163-A, which has a similar provision for warning by dial light.

NOTE

> This dial-light failure might, however, be caused by burn-out of the lamp itself, or by a fault in the wiring or switching in the lamp circuit. The procedures of paragraphs 5.3.2 to 5.3.5 may be followed whenever any doubt exists as to the exact cause.

5.3.7 NONSEQUENTIAL DIGIT CHECK.

It is possible to check any dial digit by comparison, through the CAD, with the corresponding digit on another Digit Insertion unit. For example, if unit 7 is known to be good and there is some doubt about unit 6, compare all digits in unit 6 with those in unit 7 as follows:

a. Set both dials to 0, depress B_7, and adjust the CAD for a visible beat on the monitor meter.

b. Depress B_6; the beat should be unchanged.

c. Set both dials to 1, press B_7, and adjust the CAD for a visible beat.

d. Return D_7 to 0 and depress B_6; beat should be unchanged.

e. Continue through the remaining digits, remembering that each time before B_6 is depressed the reading of D_7 must be returned to 0.

By an analogous process, any digit unit can be checked against any other to its right, provided that it is known that all digit units to the right of the suspected unit are performing properly.

5.3.8 FREQUENCY CHECK NOT REQUIRING CAD

Another type of frequency check is possible, using the 5/5.1-Mc and the 5/5.1-Mc REFERENCE signals available at subminiature connections, J150 and J157, at the rear of the chassis deck.

When a panel pushbutton is actuated, the 5/5.1–Mc signal at J150 is the output of the group of DI-1 units to the left of the actuated button (and the CAD if present). The 5/5.1-Mc REFERENCE signal (J157) is the output of the DI-1 group above and to the right of the actuated button.

Therefore, it is possible to form a 1:1 Lissajous pattern between these two signals, if the dials of the two groups of DI-1 units are set to equality. (The CAD, if installed, will terminate the left-hand group and should be set at 0 or the pattern will drift). In this way, any series of dial settings of one group of DI-1 units can be compared with the same settings on the other group.

Signals from these connectors can, of course, be compared or measured individually in any other convenient way (frequency-counter measurements, or audio-beat comparison, for instance).

5.4 REMOVAL OF MODULES FROM THE CHASSIS.

5.4.1 GENERAL.

Remove the four knurled screws on the front panel (accessible through the handles), release the cabinet clamps at the rear (if in use), and withdraw the instrument from its cabinet. (See Figure 5-2.)

CAUTION

> The power switch must first be OFF, or preferably, the power cord should be disconnected.

5.4.2 REMOVAL OF A DIGIT INSERTION UNIT.

Each digit unit is held in place by two front-panel screws (concealed under the dial strip at the top of the panel) and by a hold-down clamp in the deck at the rear of the unit. To remove a digit unit, proceed as follows:

a. Remove the dial strip, which is held in place by the two Phillips-head screws at its ends.

b. Loosen the two Allen-head setscrews in the knob, by use of a 3/32-inch hex wrench, and remove the dial. Then pull the dial lamp-holder forward out of the panel. (There is a threaded insert in the top center of the lamp-holder into which a 4-40 screw can be inserted to serve as a handle).

NOTE-DIAL INDEXING

> The shaft of each digit unit has the numeral "5" stamped on it, visible when the dial is removed. When the shaft is turned so that this numeral is up, the unit is in the "5" digit position. Prior to dial remount, make sure the dial number 5 is positioned to correspond to this marking.

c. Release the rear clamp, using a straight-bladed screwdriver in the slot of the clamp screw. Turn counterclockwise until the clamping bar swings out of the recess in the rear of the digit unit. (To reinstall the unit, it may be necessary to take an additional turn or two counterclockwise, in order to raise the clamping bar high enough to swing freely into the recess, when the clamp screw is tightened clockwise.)

d. Grasp the unit by its shaft, and at the rear, and lift vertically for about 5/8 inch until the banana plugs are disengaged. Then continue to raise the rear and angle the unit out.

5.4.3 REMOVAL OF THE CONTINUOUSLY ADJUSTABLE DECADE, CAD.

Procedures are the same as for the removal of a digit unit, described in paragraph 5.4.2, except that the EXTERNAL CONTROL/INTERNAL LOCK switch crank must be pulled off the shaft, after the dial is removed.

CAUTION

> Position this switch at EXTERNAL CONTROL before removal or remount; otherwise, the leaf-spring contact which controls lamp dimming may be damaged.

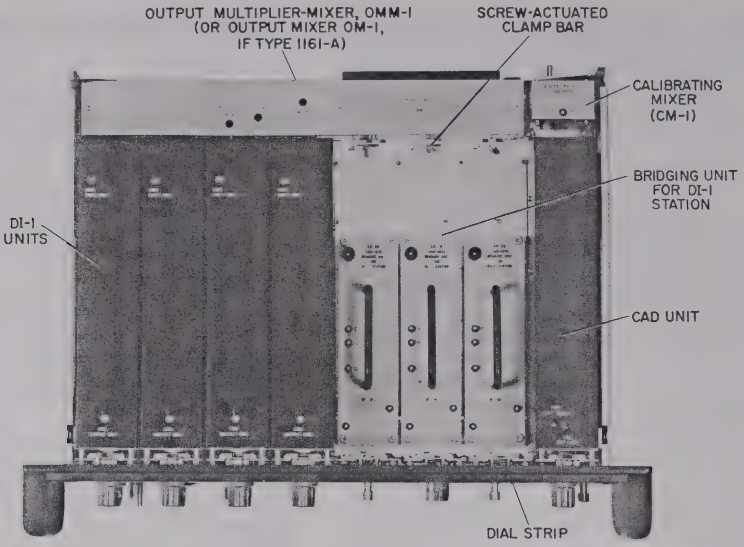

Figure 5-2.
Type 1162-A4C Synthesizer top view, cabinet removed.

NOTE-DIAL INDEXING

reinstall the CAD dial, turn the shaft clockwise to the stop. Then install the dial to read "11" (i.e., set the dial line marked "10" at the lampholder dial line marked "1", for proper dial registration).

5.4.4 REMOVAL OF THE CALIBRATING MIXER, CM-1.

Remove the three 4-40 screws from the ears at the base of the cover of the unit and lift vertically.

5.4.5 REMOVAL OF OUTPUT (MULTIPLIER) MIXER.

The Output Mixer, OM-1, (Type 1161-A, the Output Multiplier-Mixer, OMM-1 (Type 1162-A), or the Output Multiplier-Mixer, OMM-2 (Type 1163-A) is held in place by two 4-40 screws passing through the gussets on the end pans of the chassis into threaded inserts near the ends of the unit. Remove these screws, and lift the unit vertically until the banana plugs are disengaged. Small, circular posts mounted in the end plates of the unit may be used as pry-points for a screwdriver, to lift the unit clear of the banana plugs.

5.4.6 REMOVAL OF THE ANCILLARY FREQUENCY SOURCE, AFS-1 (Figure 5-3).

This unit is held in place by two 1 1/2-inch, 10-32 screws which pass vertically through the unit into threaded inserts in the deck of the chassis. With the instrument upside down, take out these screws and lift the unit vertically until the banana plugs are dis[illegible]ed.

CAUTION

Do not lift at an angle (e.g., by means of the GR874 connectors at rear only). This may damage the banana plugs. Similar precautions should be observed in removal of other modules.

5.4.7 REMOVAL OF THE POWER SUPPLY, PS-1.

This unit is secured by one 1 1/2-inch, 10-32 screw, which passes through the unit into the deck of the chassis, and by two more 10-32 screws (with special heads), which thread into the back edge of the sandwich deck. Remove these screws and lift the unit vertically until the banana plugs are disengaged. (See Figure 5-3.)

5.5 USE OF BRIDGING UNITS.

5.5.1 DIGIT-INSERTION BRIDGING UNIT.

Each synthesizer, as delivered, is provided with a spare DI-1 bridging unit (part number 1160-4070) and an accompanying dial-slot cover plate (part number 1160-8015) as separate accessories. If a DI-1 unit must be removed (for service or for any other reason), its place can be taken by the bridging unit and the synthesizer will continue to be operative, although with one less available digit.

For trouble-analysis purposes, the bridging unit may be plugged in directly in place of any removed DI-1 unit. If it is intended to keep the bridging unit installed for some time, however, it is desirable to fill the gap resulting from removal of a DI-1 unit. Transfer the last DI-1 unit to the right into the vacated position and plug in the bridging unit to the right of the result-

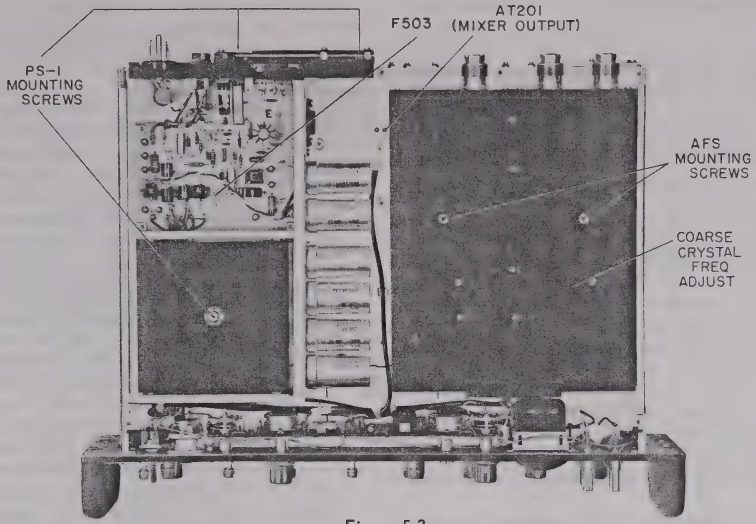

Figure 5-3.
Synthesizer bottom view, cabinet removed.

ing continuous group of DI-1 units. This will maintain proper correspondence between the digit steps engraved on the dial strip and the actual digit steps.

Synthesizers purchased only partially equipped have bridging units installed at the factory in each unfilled station. Figure 5-2 shows bridging units installed in such a synthesizer. Figure 1-2 shows cover plates installed to complete panel dress.

5.5.2 CAD BRIDGING UNIT.

When the CAD is omitted or removed, it is desirable (but not absolutely essential) to replace it with CAD Bridging Unit, 1160-4080. If this bridging unit is installed, the pushbuttons behave in more or less normal fashion. That is, when button B_8 or $B_{\text{CAD OFF}}$ (see Figures 4-6 through 4-8), or the button under any unoccupied DI-1 station in the partially equipped models, is operated, the input to the first active DI-1 unit will be 5 Mc/s (signal component 0 kc/s). If the bridging unit is not installed and the CAD OFF button is actuated, this 5-Mc input will still be applied correctly to the first active DI-1 unit.

NOTE

> If any other button is inadvertently depressed, this proper input will not be supplied, if the CAD Bridging Unit is missing.

5.5.3 OPERATION WITHOUT BRIDGING UNITS.

The primary function of the DI-1 bridging unit is to connect together the input and output banana plugs at the vacated position. These are the two plugs nearest the front of the deck, PL211-X and PL212-X (X is the digit station number I through VII). The bridging unit also supplies proper loading on the picket-fence line (PL208-X and PL209-X) and on the 42-Mc line (PL210-X), but this loading is not essential, particularly if only one or two DI-1 units are missing. So in an emergency, PL211-X and PL212-X can be connected together with a clip lead, if a bridging unit is not available, and normal operation will be achieved.

Correspondingly, signal paths can be completed to simulate the CAD bridging unit by connection of PL213 to PL216, but it is probably easier just to depress the CAD OFF button when the CAD is removed.

CAUTION

> The bridging units are designed to protect the +18V banana plug (PL207-X) from accidental grounding. If a unit is removed and replaced by a clip lead instead of a bridging unit, be careful not to ground this plug. Grounding will blow internal fuse F503 in the power supply and may do other damage (see Figure 5-3).

5.5.4 COVER PLATE 1160-8015.

This cover plate, which hides the keyhole cutout in the panel when a DI or CAD unit is missing, is held in place by one screw only, in its lower right hand corner. The left-hand-corner screwhead passes through a clearance hole in the plate.

NOTE

> For removal or installation, do not remove both screws or the lamp-switching panel, which is also held by these screws, may become dislocated.

5.6 SYSTEM TROUBLE ANALYSIS.

5.6.1 GENERAL.

The modular construction used for all three synthesizers makes it relatively easy to diagnose system trouble, particularly if spare modules of the various kinds are at hand. Suggestions for determination of the module responsible for system failure follow.

5.6.2 SINGLE DIAL-LAMP FAILURE.

If one dial lamp fails at all positions of its dial and the others behave normally, the bulb is probably burned out. Remove the lamp and inspect it. If the lamp is not defective, the associated module should be checked. DI-1 units can be compared with the CAD as described in paragraph 5.3. In the Type 1163 synthesizer, the CAD check cannot be made on the DI-4 unit. A frequency measurement at the output connector can be made to check operation of the DI-4. If the DI-4 lamp is out, and the frequency measurement at the output jack is normal, check the output jack with an oscilloscope for frequency jitter, indicating instability in the DI-4 phase-lock loop (see Section DC).

Remove any defective DI-1 unit and replace it with another, a bridging unit, or even a clip lead (refer to paragraph 5.5.3). A defective DI-4, however, can be replaced only by another DI-4 unit.

5.6.3 TOTAL DIAL-LAMP FAILURE.

If all dial lamps fail simultaneously, the trouble is probably in the power supply. Fuse F503, which plugs into a socket in the etched circuit board (accessible from below without removal of the power supply) is the most likely cause of failure. However, if the synthesizer is otherwise behaving properly, a wiring fault in the chassis-lamp circuits should be suspected. Also a defective AFS unit can sometimes cause all lamps to go out because of improper frequencies on the picket-fence or 42-Mc lines (refer to paragraph 5.6.4).

In the Type 1163, if all DI-1 lamps go out, but the DI-4 lamp does not, the 42-Mc and picket-fence section of the AFS unit can still by faulty. Failure in the 1-Mc section of the AFS can also cause total lamp failure, or an apparent DI-4 failure (in the Type 1163).

5.6.4 IMPROPER FREQUENCY GENERATION.

If lamp behavior is normal, but the self-check (refer to paragraph 5.3) or other test indicates improper frequency generation, the trouble is probably in the AFS unit, but might be in some DI unit.

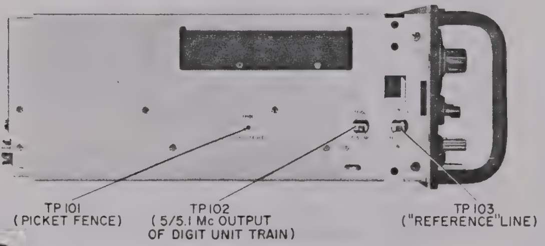

Figure 5-4. Synthesizer left-hand side view, cabinet removed (Types 1161 or 1162).

NOTE

A dial may have been installed with improper registration (refer to paragraph 5.4.2).

If the first DI-1 (number 7 in a complete unit) seems to agree properly with the CAD dial under self-check procedures of each of its digits, proceed through the DI-1 train from right to left, checking each unit in turn, until the defective one is found. If this procedure fails to locate the trouble (and particularly if the number 7 DI-1 doesn't check closely with the CAD), then test the AFS (or replace it if a spare is available).

5.6.5 FREQUENCY 10X OR 0.1X (TYPE 1161 or 1162).

If the output frequency is ten times (or one-tenth) the dial indication, the wrong dial strip has been installed in reassembly. A check that the dial strip corresponds with the installed OM-1 or OMM-1 (Type 1161-A or Type 1162-A, respectively) can be done entirely from the front of the instrument. Set up 2 c/s on the dials, throw the MONITOR switch to OUTPUT VOLTS, with AC OUTPUT COUPLING selected, and OUTPUT LEVEL at maximum. If all is proper, the MONITOR meter will follow the 2-cycle output frequency. The indication will be near the zero end of the scale, because the cutoff for ac coupling is at 30 c/s. (Incidentally, this test also checks the 0's of all the DI-1 units to the left of the 1-cycle-per-step position.)

5.6.6 INADEQUATE "CRYSTAL FREQ" RANGE.

The CRYSTAL FREQ control on the front panel permits relatively fine control of the free-running frequency of the internal master crystal oscillator. There is also a coarse control, which can be adjusted slightly, if for any reason the range of the panel control proves inadequate. The coarse control is C122, accessible through the bottom of the AFS-1 unit, without removal of the unit from the chassis (see Figure 5-3). To readjust this control, first set the fine control approximately at center. Then, measure the (free-running) output at the rear-apron connectors, 5 MC OUT (J108) or 100 KC OUT (J206), while making the adjustment.

NOTE

Use a nonmetallic screwdriver.

5.6.7 OUTPUT MISSING OR ABNORMALLY LOW.

First confirm that the OUTPUT COUPLING switch is in the AC position, if the MONITOR meter is being used for output-voltage indication. If trouble persists with this control properly set, the fault may be in the final DI-1 unit, in the chassis wiring (including the pushbutton switches), in the output-mixer module that is installed, or in the output amplifier. If the final DI-1 is at fault, the self-check (refer to paragraph 5.3) will probably fail at button B_1.

Look for +18±0.2 Vdc at J153 (rear apron) to ascertain that B+ is available from the power-supply module. If the reading is abnormal, refer to Sections BA or BB plus GA.

If B+ is present, look for the indications called for in Table 5-1 at externally available test points. With three exceptions, these trouble-analysis observations can be made at rear-apron test points and will not require instrument disassembly. However, for access to TP101, TP102 and AT201, the synthesizer must be removed from its case. These observations will help to isolate malfunction to the module level. Detailed module service instructions are given in the referenced, tabbed sections that follow.

For the observations called for in Table 5-1 the synthesizer should be synchronized with the 100-kc time base of the counter, which should be connected to LOCK SIG IN (J107 on the rear apron). Alternative trouble analysis techniques are presented in Table 5-2.

5.7 SERVICE AT THE MODULE LEVEL.

A thorough knowledge of the principles of operation, and of all the circuit arrangements by which the desired operation is achieved, is required for detailed trouble-shooting in this equipment. In separate sections of this book will be found additional descriptive matter on the principles of operation of the Main Frames and of each of the module types used in the synthesizers, together with photographs, circuit diagrams, and parts lists. Instrument servicing is relatively easy, since suspected modules can so readily be replaced by known good ones or, in the case of the DI-1 or the CAD, jumpered out. Repair service on modules can be obtained at the factory or, in most instances, at the nearest General Radio Sales Engineering Office.

TABLE 5-1

SYSTEM TROUBLE ANALYSIS
(See Figures 5-3 and 5-4)

Test Points	*Synthesizer Type*	*Normal Indications**	*Modules Involved*	*If Indication Abnormal,† Refer to Section*
J150	1161/2/3	5.0 Mc/s plus 10 kc/s x DI-1 dial readings	DI-1 (or RDI-1), AFS	DA (or DB), CA
J151	1161/2/3	5.0 Mc/s	AFS	CA
J152	1161/2/3	1.0 Mc/s	AFS	CA
J154	1162/3	50/51 Mc/s (10X J150)	OMM-1, OMM-2, DI-1 (or RDI-1), AFS	FB, FC DA (or DB), CA
J155	1161/2/3	42 Mc/s	AFS	CA
J156	1162	50 Mc/s	OMM-1, AFS	FB, CA
J156	1163	50 Mc/s minus 1 Mc/s x DI-4 dial reading	DI-4, AFS	DC, CA
J157	1161/2/3	5.0 Mc/s +10 kc/s x "replaced" DI-1 dial readings	DI-1 (or RDI-1), AFS	DA (or DB), CA
AT201	1161	Synthesizer output frequency	OM-1, OMM-1, OMM-2	FA, FB, FC
TP102	1161/2/3	5.0 Mc/s +10 kc/s x CAD major division‡	CAD	EA
J403A	1161/2/3	CAD output frequency minus "replaced" DI-1 output frequency	CM-1	EA
TP101	1161/2/3	Picket Fence waveform (Figure 5-5)	AFS	CA

NOTES:
*Frequencies above can be measured with a sensitive (0.1 V) 50-Mc counter or counter/scaler combination such as a GR Type 1144. Use an oscilloscope (such as Tektronix 543 with C/A plug-in) for the waveform at TP101.
†If signals are absent completely, chassis shorts or opens may be causing difficulty; see Sections BA or BB.
‡With B1 depressed; (B2 in Type 1163).

TABLE 5-2

SYSTEM TROUBLE ANALYSIS – ALTERNATIVE
OSCILLOSCOPE LISSAJOUS PATTERN TECHNIQUES

Rear Apron Test Points	*Synthesizer Type*	*Normal Indication Frequencies – Mc/s*		*Modules Involved*	*If Indication Abnormal, Refer to Section*
		V	*H*		
J108, J152	1161/2/3	5	1	AFS	CA
J155, J152	1161/2/3	42	1	AFS	CA
J156, J152	1163	39/50	1	DI-4	DC
J108, J156	1162	50	5	OMM-1	FB
J108, J206	1161/2/3	5	0.1	AFS	CA

NOTES: Patterns should be stationary and jitter free.
Use an oscilloscope (such as Tektronix 543, with C/A plug-in).

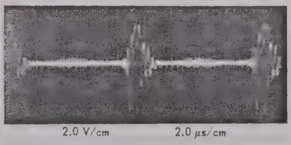

Figure 5-5.
Picket-Fence waveform at TP101.

SERVICE INSTRUCTIONS

section AA

ACCESSORIES

P/N 1160-4070 and 1160-4080

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AA-1.2 Bridging Units ____ AA-3

Form No. 1160-0160-A March 1966

GENERAL RADIO COMPANY

West Concord, Massachusetts

SECTION AA

INTRODUCTION

AA-1.1 GENERAL.

Accessory equipments covered in this section are all units peculiar to General Radio synthesizers. Most mount directly on the Main Frame chassis, either in place of standard modules, or as additions to the standard system configuration. With the exception of the DI-1 Bridging Unit, one of which is supplied with each synthesizer for a service spare, accessory equipments are optional extras.

On synthesizers purchased less than fully equipped, each unoccupied DI-1 station is furnished with a bridging unit. The same situation obtains for an unoccupied CAD station.

AA-1.2 BRIDGING UNITS.

The DI-1 Bridging Unit (P/N 1160-4070) is shown in Figure AA-1 and the schematic diagram appears in Figure AA-2. The CAD Bridging Unit (P/N 1160-4080) schematic is shown in Figure AA-3.

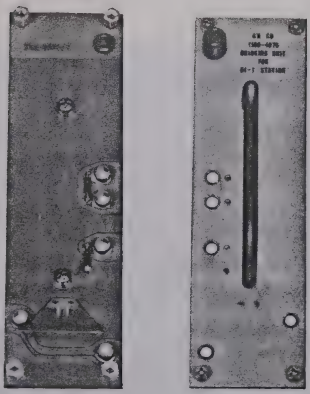

Figure AA-1. Bridging Unit for DI-1 (P/N 1160-4070).

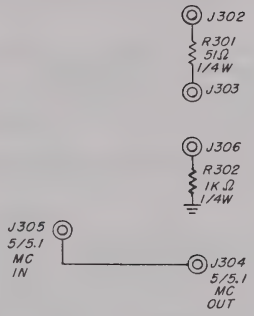

Figure AA-2. Schematic diagram for DI-1 Bridging Unit.

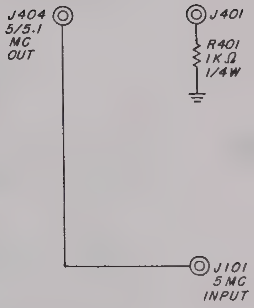

Figure AA-3. Schematic diagram for CAD Bridging Unit.

Parts List for DI-1 Bridging Unit (Figure AA-2).

REF NO	DESCRIPTION	PART NO
J302	JACK, etched-circuit type	1160-6110
J303	JACK, etched-circuit type	1160-6110
J304	JACK, etched-circuit type	1160-6110
J305	JACK, etched-circuit type	1160-6110
J306	JACK, etched-circuit type	1160-6110
R301	RESISTOR, 51 Ω ±5% 1/4 W	6099-0515
R302	RESISTOR, 1 kΩ ±5% 1/4 W	6099-2105

Parts List for CAD Bridging Unit (Figure AA-3).

REF NO	DESCRIPTION	PART NO
J101	JACK, etched-circuit type	1160-6110
J401	JACK, etched-circuit type	1160-6110
J404	JACK, etched-circuit type	1160-6110
R401	RESISTOR, 1 kΩ ±5% 1/4 W	6099-2105

SYNTHESIZER APPLICATIONS

A number of interesting applications for these synthesizers have been described in articles that have appeared in the General Radio Experimenter.

To date, applications information has been included in the following issues:

Vol 38 No. 9, September 1964
Vol 39 No. 5, May 1965
Vol 39 No. 8, August 1965
Vol 39 No. 11 and 12, November-December 1965

If you would like a free copy of these articles, simply fill out the reply card below, detach it, and drop it in the mail.

As new information becomes available, it will be published in subsequent issues. If you don't now receive the Experimenter, be sure to check the appropriate box in the reply card, so that your name can be added to our mailing list.

The editors would also appreciate a brief description of the principal applications for your GR synthesizer.

SERVICE INSTRUCTIONS

section BA

MAIN FRAME & OUTPUT AMPLIFIER

P/N 1160-4060
Chassis for Types 1161 and 1162 Synthesizers
(Including Output Amplifier P/N 1160-4040)

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- BA-2.2 AFS Connections – Signal Circuits — BA-6
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- BA-2.6 Power-Supply Connections — BA-7
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Form No. 1160-4040-A ID Number B77 February 1966

GENERAL RADIO COMPANY
West Concord, Massachusetts

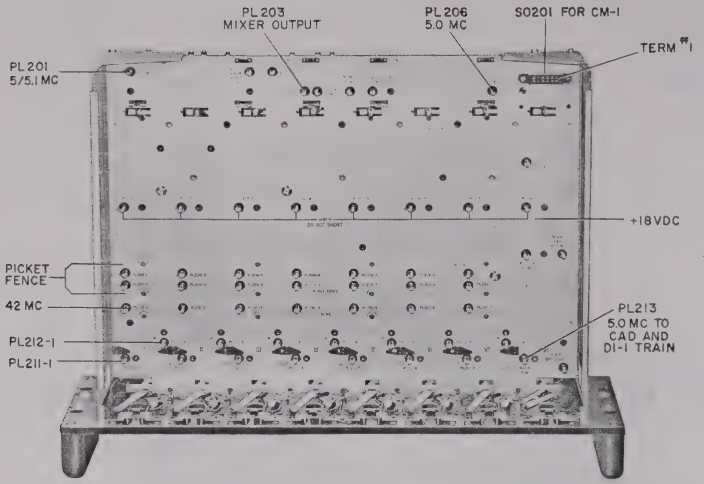
PL 203
MIXER OUTPUT
PL 206
5.0 MC
SO201 FOR CM-1
TERM #1
PL 201
5/5.1 MC
+18VDC
DO NOT SHORT
PICKET
FENCE
42 MC
PL213
5.0 MC TO
CAD AND
DI-1 TRAIN
PL212-1
PL211-1

Figure BA-1.
Synthesizer Main Frame - top deck or chassis. Callouts indicate important module-interconnection points.

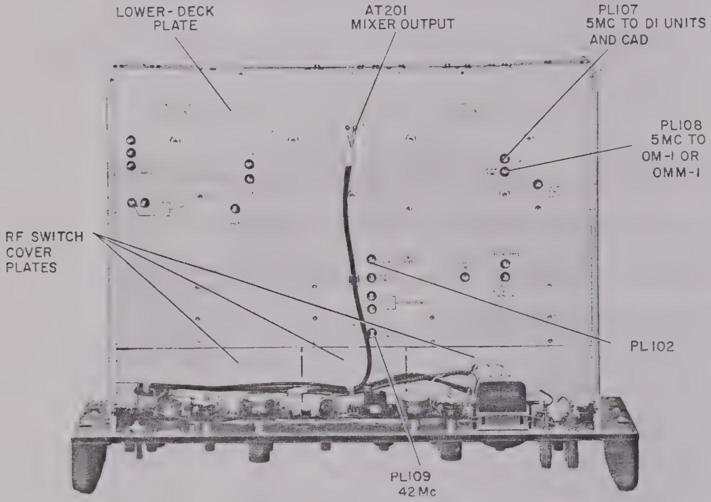
LOWER-DECK
PLATE
AT201
MIXER OUTPUT
PL107
5MC TO DI UNITS
AND CAD
PL108
5MC TO
OM-1 OR
OMM-1
RF SWITCH
COVER
PLATES
PL 102
PL109
42 Mc

Figure BA-2.
Synthesizer Main Frame - lower deck of chassis. Callouts indicate important module-interconnection points.

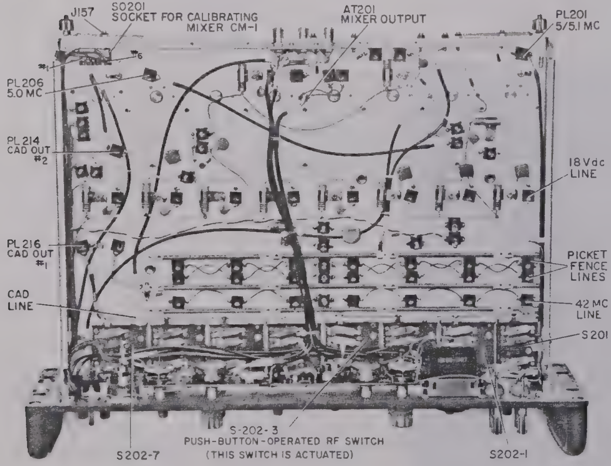
J157
SO201
SOCKET FOR CALIBRATING
MIXER CM-1
AT201
MIXER OUTPUT
PL201
5/5.1 MC
#1
6
PL206
5.0 MC
PL 214
CAD OUT
#2
18 Vdc
LINE
PL 216
CAD OUT
#1
PICKET
FENCE
LINES
CAD
LINE
42 MC
LINE
S201
S-202-3
PUSH-BUTTON-OPERATED RF SWITCH
(THIS SWITCH IS ACTUATED)
S202-7
S202-1

Figure BA-3.
Chassis lower deck with cover plates remov

SECTION BA-1

INTRODUCTION

BA-1.1 GENERAL.

Familiarity with the material contained in Sections 1 through 5 of the front part of this book is assumed. The separated subassemblies are treated in individual sections such as this.

BA-1.2 PURPOSE.

The Main Frame (Part No 1160-4060) is the foundation unit of both the Type 1161-A and Type 1162-A synthesizers. It provides mounting facilities for the plug-in modules and proper interconnections between them so that the assembly will perform as described in Sections 1 through 5 at the front of this book.

Figure BA-9, the over-all schematic, is the system interconnecting wiring diagram for the complete synthesizer.

A part of the interconnection function performed by the chassis involves rf switching, which makes it possible for the CAD unit to replace, functionally, any chosen group of DI units. Corresponding dial-light switching is also included. To constitute an operating synthesizer, the Main Frame must be equipped with a train of DI units (normally between three and seven), an AFS unit, a Power Supply, and either an OM-1 unit (for Type 1161-A) or an OMM-1 (for Type 1162-A); the CAD unit is optional.

The Main Frame is comprised of the chassis and the output amplifier. The chassis is so designed that similar modules can be interchanged with one another. In any DI station that is intentionally left vacant, a DI Bridging Unit (P/N 1160-4070) or equivalent must be installed. If the CAD unit is omitted, it is desirable (but not necessary) to replace it by a CAD Bridging Unit, P/N 1160-4080. Refer to paragraphs 3.9 and 5.5 in the front portion.

In addition to these interconnection and switching functions, the chassis mounts the Output Amplifier (P/N 1160-4040), which is an integral part of the Main Frame. This amplifier accepts signals from either the OM-1 or the OMM-1 (Type 1161-A or 1162-A) and suitably amplifies them for delivery to the synthesizer OUTPUT connector.

BA-1.3 DESCRIPTION.

BA-1.3.1 SANDWICH DECK.

The main structural parts of the chassis are the instrument front panel, two end pans to support the deck ends, and the deck itself. The deck consists of two horizontal plates, spaced 5/16 inch apart to form a "sandwich." Mounted on the plates, and captive within the sandwich, are a number of banana plugs with special molded insulating bases. Each plug is free to move a small amount horizontally, for alignment with the proper jack in the associated plug-in module. Some of the banana plugs project through the top surface of the deck to make connections to the DI modules, the OM-1 (or the OMM-1), and CAD; others protrude through the bottom surface to engage the AFS-1 Ancillary Frequency Source and the PS-1 Power Supply. Figures BA-1 and BA-2 show top and bottom views of the sandwich.

Also included within the sandwich are the flat-bladed rotary rf switches linked with the panel pushbuttons. These control the functional position of the CAD and connect the output of the replaced DI units to the calibrating mixer, as described in the front portion of this book, paragraphs 3.3.1 and 4.5. These switches are accessible for inspection if the three cover plates, which form the front portion of the bottom deck of the sandwich, are removed. These plates can be seen in Figure BA-2.

Figure BA-3 is a view of the bottom, similar to Figure BA-2, but with the three cover plates and the main lower deck-plate taken off. The eight rf switches can be seen in a row next to the front panel. The fifth switch from the left has been actuated through its panel pushbutton. Note the different orientation of the blades of the switch.

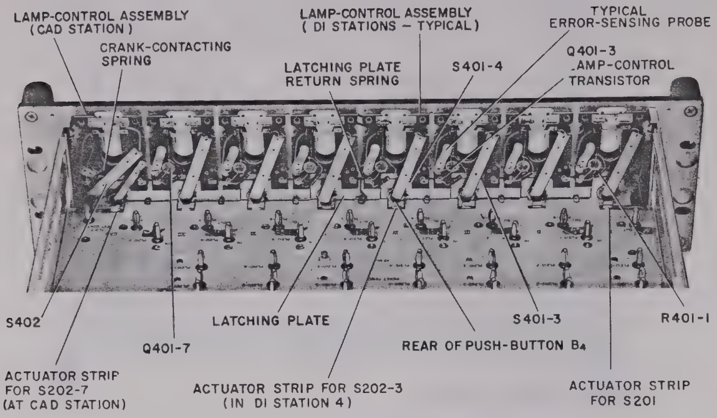
LAMP-CONTROL ASSEMBLY (CAD STATION)
CRANK-CONTACTING SPRING
LAMP-CONTROL ASSEMBLY (DI STATIONS – TYPICAL)
LATCHING PLATE RETURN SPRING
S401-4
TYPICAL ERROR-SENSING PROBE
Q401-3 LAMP-CONTROL TRANSISTOR
S402
LATCHING PLATE
S401-3
R401-1
Q401-7
REAR OF PUSH-BUTTON B4
ACTUATOR STRIP FOR S202-7 (AT CAD STATION)
ACTUATOR STRIP FOR S202-3 (IN DI STATION 4)
ACTUATOR STRIP FOR S201

Figure BA-4.
Behind-panel view (above chassis deck) of Main Frame showing details of lamp control assemblies.

In Figure BA-3 the banana plugs are visible, as well as the interconnecting wiring. Some of the plugs are identified in Figures BA-1 and BA-2, and the appropriate "PL-" number for each is marked on the sandwich plates (top and bottom).

BA-1.3.2 DIAL-LIGHT SWITCHES.

Figure BA-4 shows the top rear of the front panel, on which are mounted eight lamp-panel assemblies. Seven of these are identical, at the DI-1 stations. Each contains provisions for a dial-light assembly (see Figure BA-5).

The dial-light assembly makes a spring engagement with the pair of pins that protrude through the top of the keyhole slot in the instrument panel, to form one side of the lamp circuit. The high side of the circuit to the lamp is completed by the U-spring near the slot center, which grips the bulb reflector-holder.

Switches S401-1 through S401-7 control the dial lights at the DI-1 stations and S402 controls the CAD dial light. These switches are operated by the panel pushbuttons, which simultaneously throw the rf switches S201 and S202-1 to S202-7. The actuator strip for S202-3 is identified in Figure BA-4.

The short sheet-metal springs, called Error-Sensing Probes in Figure BA-4, in cooperation with Lamp-Control Transistors Q401-1 to Q401-7, extinguish the corresponding dial lights in case of DI-1 malfunction (refer to Section DA, on the DI-1 unit, for details).

The eighth lamp panel, at the CAD station, has no error-sensing probe or transistor. The dial-light switch for the CAD is S402, which is opened when the CAD OFF button is pushed. Rf switch S202-7, at the CAD station, is operated by the pushbutton centered under the CAD station (Figure BA-3).

The CAD lamp panel also carries a leaf-spring that, in combination with the CAD EXTERNAL CONTROL-INTERNAL LOCK crank (refer to Section EA and the chassis schematic, Figure BA-9) makes up S404, which dims the CAD dial light in the EXTERNAL CONTROL position.

The eighth switch from the left in Figure BA-3 (S201) is the same as the other seven, except that the portion of the etched board, which in other switches carries the banana plug for connection to the next succeding DI-1 unit, has been removed. The output from S201 is taken instead via coaxial cable to PL201 at the rear of the chassis. The part number of this switch assembly for DI station I is 1160-2741.

BA-1.3.3 PUSHBUTTONS.

The front-panel pushbuttons (B_1 to B_8 and $B_{CAD\ OFF}$ of Figure 4-7), shown in the front-panel view of Figures 1-1 and 1-2, are so arranged mechanically that in normal operation only one button can remain depressed at a time. Operation of any button releases any other, which has previously been actuated, to its normal, nonoperated position. Each button from B_1 to B_7, inclusive, operates two switches. For example, in Figure BA-4, lamp switch S401-4 is opened and rf switch S202-3 is operated, when button B_4 is pushed.

Button B_8, as can be seen in Figure BA-9, operates only S202-7, and $B_{CAD\ OFF}$ operates only lamp switch S402.

Figure BA-6 is a sectional view of one of the pushbutton controls, in its relationship to typical switches. The restoring force on the pushbutton body

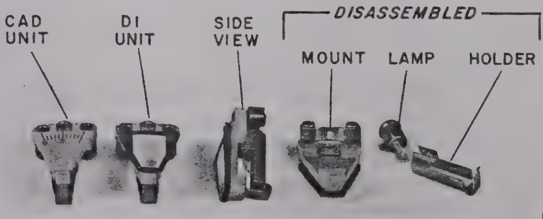
CAD UNIT
DI UNIT
SIDE VIEW
DISASSEMBLED
MOUNT
LAMP
HOLDER

Figure BA-5.
Digit-station dial-lamp panel inserts (typical).

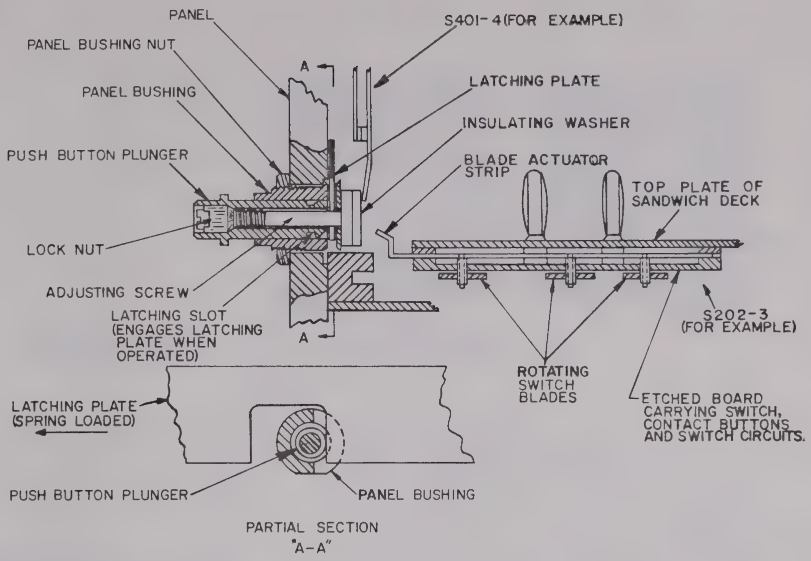
PANEL
PANEL BUSHING NUT
PANEL BUSHING
PUSH BUTTON PLUNGER
LOCK NUT
ADJUSTING SCREW
LATCHING SLOT (ENGAGES LATCHING PLATE WHEN OPERATED)
A
A
S401-4(FOR EXAMPLE)
LATCHING PLATE
INSULATING WASHER
BLADE ACTUATOR STRIP
TOP PLATE OF SANDWICH DECK
S202-3 (FOR EXAMPLE)
ROTATING SWITCH BLADES
ETCHED BOARD CARRYING SWITCH, CONTACT BUTTONS AND SWITCH CIRCUITS.
LATCHING PLATE (SPRING LOADED)
PUSH BUTTON PLUNGER
PANEL BUSHING
PARTIAL SECTION "A–A"

Figure BA-6. Section view for a typical front-panel pushbutton-switch-control assembly.

is supplied by the blade of S401, and S202 is held in its nonoperated position by its own restoring spring (shown in Figure BA-7). The latching plate, which runs horizontally across the panel in Figure BA-4, is shown in vertical section in Figure BA-6. It has a rectangular cutout at each pushbutton position and one edge of this cutout bears on the contoured pushbutton body.

When the button is pushed, the latching plate is forced to move horizontally as the edge of the cutout rides up the conical end of the pushbutton body; it then falls back into the latching slot and holds the pushbutton in its operated position.

The mechanical throw of switch S202 is factory adjusted in this operated position by the adjustable plunger in the pushbutton body.

As any button is pushed, the resulting lateral motion of the latching plate releases it from the latching slot of any other button that was previously pushed, allowing that button to fall back to normal position.

The latching plate is spring loaded into the latching slots by the wire spring shown at the center of the panel in Figure BA-4.

BA-1.3.4 OUTPUT AMPLIFIER — 1160-4040.

The Output Amplifier assembly is mounted against the lower rear of the front panel, as seen in Figure BA-8. In addition to the actual amplifier circuits, this board contains (and is mounted to the panel by) the OUTPUT LEVEL control (R401), the CRYSTAL FREQ control (R407), the OUTPUT COUPLING switch (S412), and the MONITOR switch (S411). In addition, the output-voltmeter circuits are mounted on this board.

SECTION BA-2

PRINCIPLES OF OPERATION

NOTE

Refer as required to the schematic diagrams of the Main Frame, Figure BA-9, and of the Output Amplifier, Figure BA-10.

BA-2.1 GENERAL.

The Main Frame serves to interconnect the modules of the synthesizer to produce an operating unit. In order to explain these interconnections, it is first necessary to comment briefly on the functioning of these various modules.

In Figure 4-1 of the main section of this book there appears a block labeled "Frequency Synthesizing Circuits." The separate kinds of modules included in this block will now be considered. The modules involved are:

1. AFS-1 Ancillary Frequency Source,
2. DI-1 Digit-Insertion Unit (type 1),
3. CAD Continuously Adjustable Decade.

BA-2.2 AFS CONNECTIONS—SIGNAL CIRCUITS.

The primary function of the AFS-1 Unit is to supply a "starting" frequency of 5.0 Mc/s to the first DI-1 unit in a train of DI-1 units and to the CAD unit, to supply a signal at 42 Mc/s to all DI-1 units and to the CAD unit, and to provide a "picket fence" of frequencies (spaced at 100-kc intervals from 3.0 to 3.9 Mc/s) to all installed DI-1 units.

NOTE

> Discussion of how these freqencies are employed in the DI-1 units and in the CAD unit will be found in Sections DA and EA of this book. Analysis of the method by which these frequencies are coherently derived in the AFS-1 is provided in Section CA.

Figure 4-6 and 4-7 of the main section of this book show the signal path through the DI units and pushbutton-operated switches. The input and output connections to each DI for this signal path are provided by the series of banana plugs, PL211-X and PL212-X, visible nearest the panel in Figure BA-1. These plugs are integral parts of the rf switch assemblies previously noted (Figures BA-3 and BA-7). PL212-1 through PL212-7 are signal-input connectors to the several DI-1 units; PL211-1 through PL211-7 are the corresponding outputs. The connection of the 5.0-Mc starting frequency (from the AFS unit to the sandwich) is furnished by PL107 (Figure BA-2).

In order to perform its function, each DI-1 must receive a 42-Mc input and a picket-fence input. The 42-Mc output from the AFS enters the sandwich via PL109 (Figure BA-2), whence it is distributed to the DI-1 units by way of PL210-1 to PL210-7, and to the CAD by PL210-8 (Figure BA-1). The picket fence is delivered push-pull at plugs PL105 and PL106 (Figure BA-2) and distributed on the parallel lines through PL208-1 to PL208-7 and PL209-1 to PL209-7 (Figures BA-1 and BA-3).

As indicated in Figure 4-1, 5.0 Mc/s is also delivered, in the Type 1161-A, to the Output Mixer module OM-1 or, in the Type 1162-A, to the Output Multiplier Mixer OMM-1. This 5-Mc output from the AFS is isolated from the starting 5 Mc/s in the AFS and delivered independently to the sandwich, at PL108 (Figure BA-2), which is directly connected to PL206 (Figure BA-1).

The only other rf output from the AFS into the sandwich is 1.0 Mc/s via PL101. Although this signal is not made use of in the Types 1161-A and 1162-A synthesizers, it is available (after a 1000-ohm isolating resistor) at J152 at the rear edge of the sandwich.

BA-2.3 AFS CONNECTIONS—AUXILIARY CIRCUITS.

There are four other banana-plug connections between the AFS and the sandwich. PL111 carries a connection from CRYSTAL FREQ control potentiometer R407 (Figure BA-8) to the Master Frequency Section of the AFS (see Section CA for details). PL110 con-

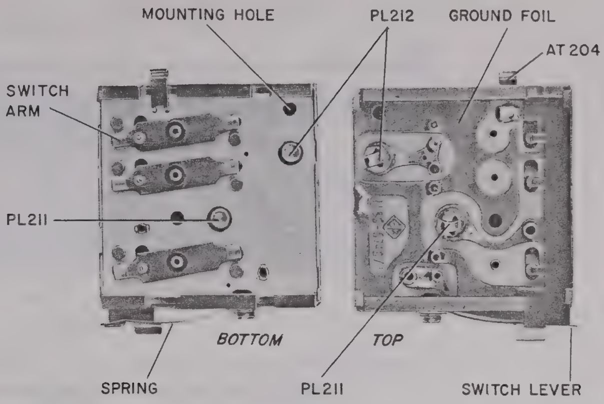

Figure BA-7.
Special rf switch assembly used in S202-1 through S202-7.

nects the error voltage of the AFS crystal-lock phase detector to the MONITOR meter circuits via the Output Amplifier. Two independent +18-volt supply inputs to the AFS enter via PL102 and PL103 (Figure BA-2).

BA-2.4 CAD AND CM-1 CONNECTIONS.

In addition to the +18-volt input, there are five other plug connections between the sandwich and the CAD (see Figures BA-1 and BA-3). One is 5.0 Mc/s, which is the same as the starting-frequency connection to the DI-1 train discussed in paragraph BA-2.2. This plug, PL213, is an integral part of rf switch S202-7. Another connection is the EXTERNAL CAD CONTROL input to the CAD, via PL217, which is directly connected to the front-panel binding post marked for this function.

The 42-Mc input connection via PL210-8 is directly in parallel with PL210-1 to PL210-7, discussed in paragraph BA-2.2. There are two outputs at the CAD frequency (between 4.99 and 5.11 Mc/s, continuously variable; see Section EA.) One of these, already mentioned, is PL216 and connects via the CAD LINE to the array of rf switches (see Figure BA-3 and Figure 4-7). The other CAD output, at PL214, connects to terminal 1 of SO201 (Figure BA-3 or BA-1). SO201 receives the Calibrating Mixer module CM-1, the use of which is described in paragraph 4.5 and in Section EA.

The other input to the Calibrating Mixer is the REF LINE shown in Figures 4-6 and 4-7. This line runs along the side of the rf switches opposite the CAD LINE. It is not visible at the switches in Figure BA-3, as it is buried in a recessed slot in the front support bar of the sandwich, but its coaxial-line connection to terminal 6 of SO201 can be seen.

BA-2.5 OUTPUT CONNECTIONS.

From Figure 4-1 plus Figures 4-6 and 4-7, it can be seen that the signal output of the synthesizing circuits connects to the OM-1 (Type 1161-A) or the OMM-1 (Type 1162-A). The actual connection, shown in Figure BA-3, is by a coaxial cable from S201 to PL201. The other input to the OM-1 (or OMM-1) — 5.0 Mc/s at PL206 — has already been discussed. The internal circuitry of the OM-1 will be found in Section FA and the OMM-1 circuitry in Section FB.

In either case, the output of the final mixer, f_o, is taken at PL203 (Figure BA-1), which connects to AT201 through the bottom deck (Figure BA-3) and is carried by coaxial cable to AT411 at OUTPUT LEVEL potentiometer, R401 (Figure BA-8).

The 5.0-Mc input at PL206 is also connected (through a 1-kΩ resistor) to J151 and the 5/5.1 Mc/s at PL201 similarly is available, through a 1-kΩ series resistor, at J150.

Two other outputs, 50.0 Mc/s at J156, via PL250, and 50/51 Mc/s at J154, by way of PL251 (in each case through 1-kΩ isolating resistance), are available only in the Type 1162-A, with the OMM-1 plugged in. Available voltage at these four ancillary jacks is about 0.1-volt across 1-kΩ. Except in early models, another output jack, J157, is mounted on the rear edge of the sandwich. This jack is connected to the REFERENCE line and makes available the 5- to 5.1-Mc output from the group of DI-1 units "replaced" by the CAD.

BA-2.6 POWER-SUPPLY CONNECTIONS.

There are eight banana-plug connections through the bottom deck to the power supply. Four of these, PL305, PL306, PL307, and PL308, carry the input power line out of the power supply to the panel POWER switch and back again. Three others, PL301, PL302, and PL303, are separately filtered +18-Vdc outputs (see Section GA for details on the power supply).

The +18-volt #1 line (at PL302) feeds regulated voltage, through individual LC filters in the sandwich, to all the installed DI-1 units and the CAD at plugs PL207-1 through PL207-7 and PL215. This output also supplies some of the AFS circuits via PL103 (see Section CA). The +18-volt #2 line is separately filtered and supplies the Picket-Fence section of the AFS by way of PL102. The third output, +18-volt #3 line, is used by the Output Amplifier. Available at PL303, it connects to AT418 on the Output Amplifier (Figure BA-8).

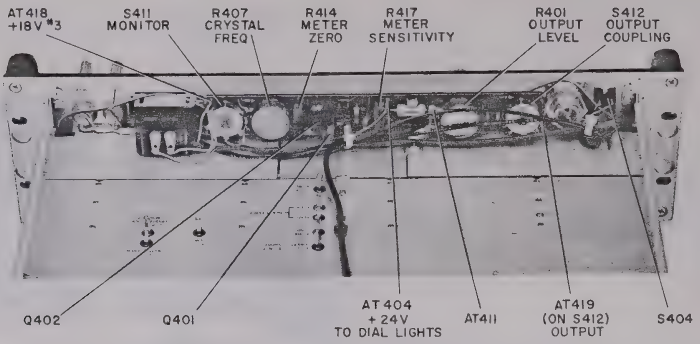

Figure BA-8. Behind-panel view (below-chassis deck) of Main Frame showing details of the Output Amplifier 1160-4040 (board in center).

The eighth connection to the power supply, PL304, brings out +24 volts unregulated to supply the dial lights. It is directly connected to an insulated tie-point, AT404, on the Output Amplifier board (Figure BA-8). For details on the dial-light circuits and switching operation, see Figure 4-8 and the Main Frame schematic diagram, Figure BA-9.

BA-2.7 OUTPUT AMPLIFIER.

The circuits of the Output Amplifier proper, which are a part of Output Amplifier assembly P/N 1160-4040, are shown on schematic diagram, Figure BA-10. (See also Figure BA-8.) The signal from the output mixer, f_o, connected to OUTPUT LEVEL control, R401, is amplified by Q401 and Q402 and connected to the output connector J405 by jumper wire from AT419.

Q401 and Q402 are used as a modified complementary Darlington pair. The voltage gain is a little greater than 2, due to the feedback division ratio of R411 and R413. The output, in the AC COUPLING position (selected by S412), is via blocking condenser C404 (paralleled by C403 to extend high-frequency performance). The output impedance of the amplifier is low (about 7 ohms) and the MONITOR meter reads output volts, from 0 to 2. The voltmeter rectifier CR401 and associated components are also mounted on this board. Since the MONITOR meter is normally zero-center, it is bucked to zero reading at zero output volts, by current through R415.

When S412 is in the DC position, the meter circuits are disconnected and the output is taken directly from the arm of potentiometer R401, the OUTPUT LEVEL control.

For mechanical convenience, MONITOR switch S411 is also mounted on the Output Amplifier board. This switch connects the meter to the chosen function — CAD CAL, OUTPUT VOLTS or LOCK TO EXT STD. For the first and third of these functions, leads are brought to the switch from the appropriate points in the sandwich. The "Rectified CAD Beat," at AT417, comes from terminal 4 of SO201, and the "Crystal Lock Monitor" enters at AT413 from PL110 at the AFS station. The "Crystal Freq" line, from the AFS at PL111, also comes to S411 and R407 on the Output Amplifier board.

BA-2.8 AVAILABLE CHASSIS TEST POINTS.

Test points are accessible externally. Among these are the subminiature coaxial jacks, J150 through J157 on the rear edge of the sandwich, at which checks can be made of +18 V, 1 Mc/s, 5 Mc/s, 5/5.1 Mc/s (as set by the panel dials), 42 Mc/s, 50 Mc/s, 50/51 Mc/s, and the REFERENCE-line signal (5/5.1 Mc/s). (The 50-Mc and 50/51-Mc jacks are energized only in the Type 1162-A.) J157, which is not installed in some early production units, is connected to the REFERENCE line and gives access to the output signal from the DI-1 unit immediately above any actuated push-button. (When the button under the CAD is pushed, 5.0 Mc/s appears at J157.) The 5/5.1-Mc signal as it emerges from the train of DI-1 units can also be measured at TP102, in the left-hand end pan (Figure 5-4). At adjacent TP103, the signal on the REFERENCE line (see Figure 4-6) is available behind R100.

If a dial light goes out, and there is a suspicion that the failure may be due to bulb burnout rather than to a DI malfunction, one can readily short out the error-sensing transistor, Q401-n. If the chassis is pulled forward out of its cabinet about one-half inch, the brass angle strips, carrying the pins on which the dial-light panel mounts, will be exposed. Each angle strip is connected to the low side of the lamp bulb; test of the bulb may be made by the momentary grounding of this strip (see Figure BA-4).

Of course, test points are also available at each sandwich-deck banana plug when the mating module is removed.

BA-2.9 DUPLICATE JACKS AT REAR.

Except in early production models, three BNC jacks are mounted on a rear bracket and connected in parallel with corresponding panel connectors. These rear jacks, J401A, J403A, and J405A, make available at the rear of the instrument the EXTERNAL CAD CONTROL, the BEAT output, and the main OUTPUT of the synthesizer.

SECTION BA-3

SERVICE AND MAINTENANCE

BA-3.1 CHASSIS MAINTENANCE.

Little or no maintenance should be required on the chassis. If mechanical trouble should develop in the rf switches, remove the three cover plates (see Figures BA-2 and BA-3). Remove the center plate first, then the side plates. If a switch has to be removed for repair or replacement, it may be necessary to reset the plunger of its pushbutton for proper switch throw. To adjust the plunger, pull off the nylon pushbutton cap. This exposes the coaxial plunger and lock nut (Figure BA-6). With the button actuated, loosen the lock nut with a suitable hollow tubular spanner (such as GR tool TO170) and, while holding the pushbutton body from turning, screw the plunger in or out as required for proper centering of the the switch blades on the contacts. Retighten the lock nut securely.

If for any reason it becomes necessary to inspect the interior of the sandwich, turn the instrument upside down, with the bottom plates of the sandwich deck uppermost, and proceed as follows:

CAUTION

Do not invert the Main Frame with the lower-deck plate removed. All banana plugs are held in place by the plate.

a. Remove the switch cover plates.

b. Disconnect the coaxial output cable at AT201 and AT202 (Figure BA-2).

c. Remove the 23 #4-40 screws in the deck and the 6 #4-40 screws in the end pans.

d. Dismount the angle bracket that supports the three BNC connectors at the rear of the sandwich.

e. Then lift the lower-deck plate vertically, to clear the plugs, and slide it out to the rear.

When reinstalling the cover plate, make sure that all plugs (through both top and bottom decks) are properly seated in their locating holes before finally tightening all screws.

BA-3.2 ELECTRICAL CHECKS – OUTPUT AMPLIFIER.

Table BA-1 gives typical voltage measurements at the specified points in the amplifier circuit. These checks must be made with the normal complement of modules installed in the chassis.

Additional test conditions, under which the voltages given in the table were obtained, call for the frequency dials to be set to 100 kc/s and for S412 (OUTPUT COUPLING) to be in its AC position. A reading of +17.8 ±0.2 Vdc should be obtained at AT418. With the Type 1806-A Electronic Voltmeter connected to read output volts, and S411 placed in its OUTPUT VOLTS position, the two trimpot controls adjacent to the bottom edge of the board should be adjusted, if necessary, to achieve correspondence between the indication on the front-panel meter and that on the Type 1806-A meter (see Figures BA-8 and BA-10).

With R401 in fully CCW position, both meters should read 0 volts. If the panel-meter reading is abnormal, adjust it with R414, the "Meter Zero" control.

Adjust R401 for 2.0 volts, rms, output. If the panel meter reading is at variance, adjust the indication with R417, the "Meter Sensitivity" control.

TABLE BA-1

DC VOLTAGES FOR A PROPERLY FUNCTIONING OUTPUT AMPLIFIER (P/N 1160-4040)

(See Figure BA-10)

Stage	*Collector*	*Base*	*Emitter*
Q401	1.05	13.0	13.6
Q402	7.4	0.65	0

Notes: Taken with a Type 1806-A Electronic Voltmeter. Tolerance ±10%.

PARTS LIST

CAPACITORS

REF NO	DESCRIPTION	PART NO
C101	Ceramic, 0.1 μF +80-20% 50 V	4403-4100
C102	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C201	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C202	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C203-1	Ceramic, 2.2 μF ±20% 25 V	4400-2080
C203-2	Ceramic, 2.2 μF ±20% 25V	4400-2080
C203-3	Ceramic, 2.2 μF ±20% 25 V	4400-2080
C203-4	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C203-5	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C203-6	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C203-7	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C203-8	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C301	Ceramic, 0.02 μF +80-20% 50 V	4402-3200
C302	Ceramic, 0.02 μF +80-20% 50 V	4402-3200

INDUCTORS

REF NO	DESCRIPTION	PART NO
L101	Choke, iron core, 22 μH ±10%	4300-6600
L102	Choke, iron core, 22 μH ±10%	4300-6600
L201	Choke, iron core, 22 μH ±10%	4300-6600
L202	Choke, iron core, 22 μH ±10%	4300-6600
L203-1 through L203-8	Choke, iron core, 22 μH ±10%	4300-6600
L204	Choke, iron core, 22 μH ±10%	4300-2600

JACKS

REF NO	DESCRIPTION	PART NO
J150 through J156	Coaxial, miniature, bulkhead jack, 10-32 thread	4260-1288
*J157	Coaxial, miniature, bulkhead jack, 10-32 thread	4260-1288
J401	Binding post, insulated	0939-9835
J402	Binding post	0938-9834
J403	Binding post, insulated	0938-9835
J404	Binding post	0938-9834
J405	GR874, coaxial, panel	0874-9479
J406	Banana, panel mount	0874-6690
*J401A	Coaxial, type BNC, bulkhead jack	4230-2300
*J403A	Coaxial, type BNC, bulkhead jack	4230-2300
*J405A	Coaxial, type BNC, bulkhead jack	4230-2300

PLUGS

REF NO	DESCRIPTION	PART NO
PL101 through PL111	Banana, with special mount	1160-2120
PL201 through PL206	Banana, with special mount	1160-2120
PL207-1 through PL207-7	Banana, with special mount	1160-2120
PL208-1 through PL208-7	Banana, with special mount	1160-2120
PL209-1 through PL209-7	Banana, with special mount	1160-2120
PL210-1 through PL210-8	Banana, with special mount	1160-2120
PL211-1	Banana part of switch assembly	1160-2741
PL211-2 through PL211-7	Banana part of switch assembly	1160-2740

PLUGS (Cont)

REF NO	DESCRIPTION	PART NO
PL212-1 through PL212-7	Banana part of switch assembly	1160-2740
PL213 through PL217	Banana, with special mount	1160-2120
PL250	Banana, with special mount	1160-2120
PL251	Banana, with special mount	1160-2120
PL301 through PL308	Banana, with special mount	1160-2120

RESISTORS

REF NO	DESCRIPTION	PART NO
*R100	Composition, 1kΩ ±5% 1/4 W	6099-2105
R101	Composition, 1kΩ ±5% 1/4 W	6099-2105
R102	Composition, 1kΩ ±5% 1/4 W	6099-2105
R103	Composition, 1kΩ ±5% 1/4 W	6099-2105
R104	Composition, 1kΩ ±5% 1/4 W	6099-2105
R105	Composition, 470Ω ±5% 1/4 W	6099-1475
R106	Composition, 1kΩ ±5% 1/4 W	6099-2105
R107	Composition, 180Ω ±5% 1/4 W	6099-1185
R108	Composition, 100Ω ±5% 1/4 W	6099-1105
R401-1 through R401-7	Composition, 1.5 kΩ ±5% 1/2 W	6100-2155
R402	Power, 470Ω ±5% 3 W	6680-1475

SWITCHES

REF NO	DESCRIPTION	PART NO
S201	Special rf assembly	1160-2741
S202-1 through S202-7	Special rf assembly	1160-2740
S401-1 through S401-7	Lamp part of DI dial assembly	1160-2100
S402	Lamp part of CAD dial assembly	1160-2090
S403	Toggle, DPST	7910-1300

TRANSISTORS

REF NO	DESCRIPTION	PART NO
Q401-1 through Q401-7	Type 2N1304	8210-1304

CIRCUIT-BOARD ASSEMBLIES

REF NO	DESCRIPTION	PART NO
——	Lamp control (DI Station)	1160-2100
——	Lamp control (CAD Station)	1160-2090
——	Assembly, output amplifier, etched-circuit board	1163-4040

MISCELLANEOUS

REF NO	DESCRIPTION	PART NO
——	Knob, DI-1 control	1160-1300
——	Knob, CAD control	1160-1310
——	Knob, pointer skirt	5530-0400
M401	Edgewise, panel, 100-0-100 μA±3%, 461 Ω ±20%	5730-1382
P401-1 through P401-7	Lamp, incandescent, #327	5580-0400
SO201	Connector, multiple	4230-2706

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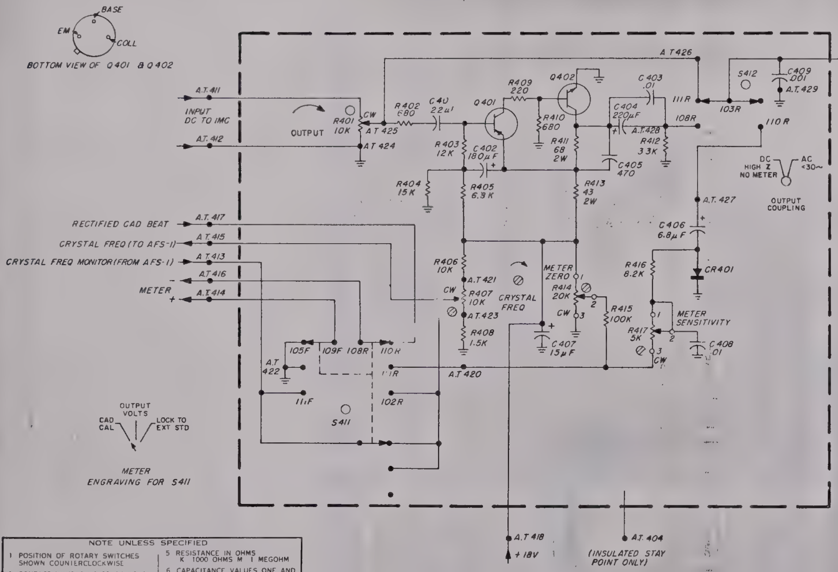
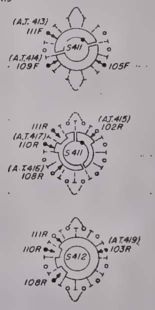
*Not on early production units.


BASE
EM
COLL
BOTTOM VIEW OF Q401 & Q402
A.T. 411
INPUT DC TO IMC
A.T. 412
OUTPUT
R401 10K
CW
A.T. 425
A.T. 424
R402 680
C401 22µF
Q401
R409 220
Q402
R410 680
R411 68 2W
R403 12K
C402 180µF
R404 15K
R405 6.8K
R413 43 2W
C403 .01
C404 220µF
A.T. 428
R412 3.3K
C405 470
A.T. 426
111R
108R
103R
110R
S412
C409 .001
A.T. 429
A.T. 419
OUTPUT
DC HIGH Z NO METER
AC <30~
OUTPUT COUPLING
A.T. 427
C406 6.8µF
CR401
RECTIFIED CAD BEAT
A.T. 417
CRYSTAL FREQ (TO AFS-1)
A.T. 415
CRYSTAL FREQ MONITOR (FROM AFS-1)
A.T. 413
A.T. 416
METER
A.T. 414
R406 10K
A.T. 421
R407 10K
CRYSTAL FREQ
A.T. 423
R408 1.5K
METER ZERO
R414 20K
C407 15µF
R415 100K
R416 8.2K
R417 5K
METER SENSITIVITY
C408 .01
105F
109F
108R
110R
111R
A.T. 422
111F
102R
S411
A.T. 420
OUTPUT VOLTS
CAD CAL
LOCK TO EXT STD
METER ENGRAVING FOR S411
A.T. 418
+18V
A.T. 404
(INSULATED STAY POINT ONLY)


(A.T. 413) 111F
(A.T. 414) 109F
S411
105F
111R
(A.T. 417) 110R
(A.T. 416) 108R
(A.T. 415) 102R
S411
111R
110R
108R
S412
(A.T. 419) 103R

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS
7. ○ KNOB CONTROL
8. ○ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

Figure BA-10.
Schematic diagram for Output Amplifier 1160-4040.

PARTS LIST
OUTPUT AMPLIFIER

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C401	Ceramic, 22 µF ±20% 25 V	4400-2080
C402	Electrolytic, 180 µF 6 V	4450-5300
C403	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C404	Special, 220 µF ±20% 10 V	1160-0410
C405	Ceramic, 470 pF ±10% 500 V	4404-1478
C406	Electrolytic, 6.8 µF ±20% 6 V	4450-4800
C407	Electrolytic, 0.15 µF ±20% 20 V	4400-2080
C408	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C409	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
	RESISTORS	
R401	Potentiometer, composition, 10 kΩ ±10%	6047-3109
R402	Composition, 680 Ω ±5% 1/4 V	6099-2225
R403	Composition, 12 kΩ ±5% 1/4 V	6099-2155
R404	Composition, 15 kΩ ±5% 1/4 V	6099-2395
R405	Composition, 6.8 kΩ ±5% 1/4 V	6099-2155
R406	Composition, 10 kΩ ±5% 1/4 V	6099-3105
R407	Potentiometer, composition, 10 kΩ ±10%	6020-0400
R408	Composition, 1.5 kΩ ±5% 1/4 V	6099-2155
R409	Composition, 220Ω ±5% 1/4 V	6099-1225
R410	Composition, 680Ω ±5% 1/4 V	6099-1680
R411	Wire-wound, 68Ω ±5% 2 V	6760-0685
R412	Composition, 3.3 kΩ ±5% 1/4 V	6099-2335
R413	Wire-wound, 43Ω ±5% 2 V	6760-0435
R414	Potentiometer, wire-wound, 20 kΩ ±10%	6059-3209
R415	Composition, 100 kΩ ±5% 1/4 V	6099-4105
R416	Composition, 8.2 kΩ ±5% 1/4 V	6099-2825
R417	Potentiometer, wire-wound, 5 kΩ ±10%	6059-2509
	MISCELLANEOUS	
CR401	Diode, type 1N34(S)	6082-1003
S411	Switch, rotary wafer	7890-3840
S412	Switch, rotary wafer	7890-3850
Q401	Transistor, type 2N3250	8210-1089
Q402	Transistor, type 2N2218	8210-1028

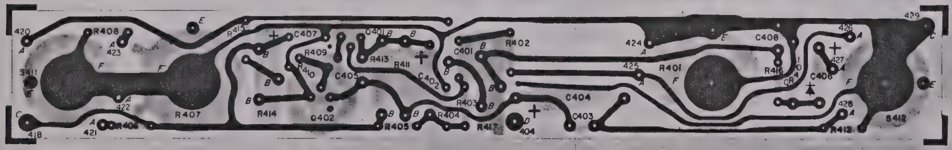

420
R408
423
E
R415
C407
C401
R409
R413
R411
C405
C402
R402
424
425
R401
C408
R416
CR401
C406
426
427
428
429
S411
422
R407
R414
Q402
R405
R404
R417
R403
404
C404
C403
R412
S412
418
421
R406
F
A
B
C
E

Figure BA-11.
Etched-circuit assembly (P/N 1160-4040).

NOTE: The number appearing on the foil side is not the part number.

SERVICE INSTRUCTIONS

section BB

MAIN FRAME & OUTPUT AMPLIFIER

P/N 1163-4060
Chassis for Type 1163 Synthesizers
(Including Output Amplifier P/N 1163-4040)

TABLE OF CONTENTS

Section BB

BB-1.1 General — BB-3
BB-1.2 Purpose — BB-3
BB-1.3 Differences from Main Frame 1160-4060 — BB-3
BB-2.1 Electrical Checks, Output Amplifier — BB-4

Form No. 1163-4060-A   ID Number B75   February 1966

GENERAL RADIO COMPANY
West Concord, Massachusetts

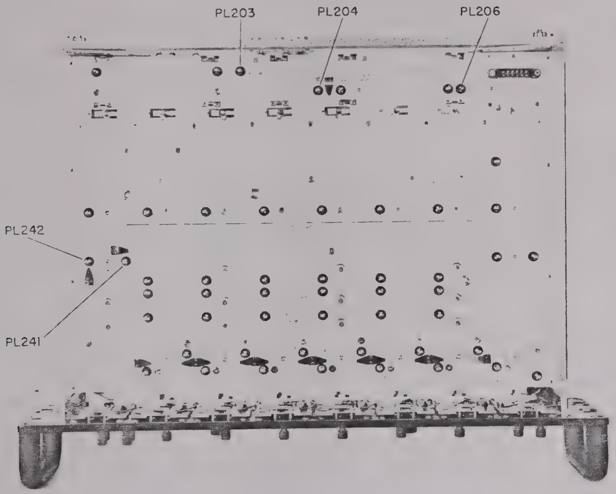

PL203
PL204
PL206
PL242
PL241

Figure BB-1.
Synthesizer Main Frame - top deck of chassis. Callouts indicate important module interconnection points.

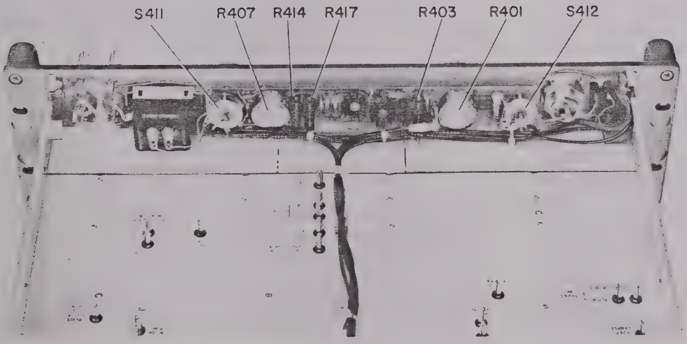

S411
R407
R414
R417
R403
R401
S412

Figure BB-2.
Synthesizer Main Frame - Output Amplifier detail on chassis lower deck.

SECTION BB

BB-1.1 GENERAL.

Inasmuch as Main Frame 1163-4060 in nearly identical with the basic Main Frame (1160-4060), described in detail in Section BA of this manual, the material of Section BA will not be repeated here. This section will cover only the differences between the two.

BB-1.2 PURPOSE.

The Main Frame (1163-4060) is the foundation for the Type 1163 synthesizer and provides mounting facilities for, and interconnections between, the plug-in modules. It also incorporates the final stages of the Output Amplifier (an output preamplifier is included in the Output Multiplier-Mixer, OMM-2).

A completely filled Type 1163-A Main Frame contains one less DI-1 unit than is the case in a corresponding Type 1161-A or 1162-A model. The missing DI-1 unit, at the left-hand digit station, is replaced by a DI-4 unit (described in Section DC). The space allotted to the OM-1 or OMM-1 module in chassis 1160-4060 is occupied by the OMM-2 module in the Type 1163-A chassis. The DI-4 unit generates megacycle steps in the synthesizer output by supplying selectable frequencies from 50 to 39 Mc/s to the low-level mixer in the OMM-2. Since the DI-4 and the OMM-2 require different inputs, outputs, and interconnections than are available in the Types 1161/1162 Main Frame, the Type 1163-4060 Main Frame chassis differs primarily in these regions. Mounting arrangements and interconnections elsewhere are identical, except for minor differences in the Output Amplifier.

BB-1.3 DIFFERENCES FROM MAIN FRAME 1160-4060.

The major differences can easily be seen by comparison of schematic diagrams, Figure BA-9 in Section BA and Figure BB-3 in this section.

BB-1.3.1 SANDWICH DECK (Figures BB-1 and BB-2).

The deck and internal wiring are identical with that of 1160-4060, except where the DI-4 unit and the OMM-2 mount. At the DI-4 location (Station I), there are no input banana plugs for 42 Mc/s or the Picket Fence; instead, plug PL242 supplies a 1-Mc input. PL242 is connected within the sandwich to the 1.0-Mc line where it emerges from the AFS unit at PL101. The DI-4 output is taken by PL241 and carried by a coaxial line within the sandwich to PL204 at the Output Mixer station.

At the Output Mixer station, the 5/5.1 input via PL201 is the same as in the other chassis, except that the source of signal is the last pushbutton-controlled rf switch (S202-1) under the last DI-1 unit at digit station 2). The output from the OMM-2 station is at PL206, near the right-hand end of the station. PL203 (50/51 Mc/s output to J154) is at the same location as the corresponding PL251 in chassis 1160-4060; PL204 brings out 50 to 39 Mc/s to a rear-apron jack, J156. (In chassis 1160-4060, J156 receives 50 Mc/s only, from PL250 of that chassis.)

In the sandwich deck, the rf switch under digit station 1 and its associated pushbutton are omitted, as previously noted.

BB-1.3.2 PUSHBUTTON AND DIAL LIGHTS.

The pushbutton and dial-light circuitry is exactly the same as in chassis 1160-4060 (Section BA) except that the left-hand pushbutton is omitted. The dial light at station 1, however, is still wired to give warning of phase-lock failure in the DI-4 unit (refer to Section DC and the schematic of the Type 1163-A chassis, Figure BB-3, for details).

BB-1.3.3 OUTPUT AMPLIFIER 1163-4040 (Figures BB-4 and BB-5).

The Output Amplifier assembly is mounted behind the lower center section of the front panel. Board size and mounting arrangements are the same as for the output amplifier of the 1160-4060 Main Frame. MONITOR switch, S411, and its circuits are identical to corresponding components on Output Amplifier 1160-4060, as are the voltmeter circuits (refer to Section BA, paragraph BA-2.6).

The Output Amplifier itself is somewhat different. In Main Frame 1163-4060, Q401 is an amplifier, with a voltage gain of about 2, for the output signal from the preamplifier in the OMM-2 (refer to section FC). L401 and R409 are compensating elements for the high-frequency end of the band. Q402 is an emitter-follower driver for the push-pull class–A emitter-follower output stages, Q403 and Q404.

In the 1163-4040 amplifier, the screwdriver-operated output switch S412 inserts or shorts out 51-ohm resistors in the lines to the front and rear output connectors of the 1163-4060 chassis (J405 and J405A). The output voltage, metered at the driving side of these resistors, is taken from the low output impedance emitter-follower output stage.

R403 is a bias-setting potentiometer that can be adjusted to produce ≈9.5 Vdc at the junction of R418 and R419, to minimize harmonic distortion in the amplifier.

BB-1.3.4 CHASSIS TEST POINTS.

The available chassis test points on the 1163-4060 Main Frame are the same as those on the 1160-4060 (Section BA) except as follows:

1. Both sides of the Picket-Fence line are available, at TP101 and TP104, in the left end pan, instead of only one side as in 1160-4060.
2. J156 provides (through a 1-kΩ isolating resistor) the output frequency of the DI-4 unit — 50 to 39 Mc/s as the dial is changed from 0 to 11. In the 1160-4060 a single frequency, at 50 Mc/s, appears at the corresponding connection.

BB-1.3.5 MAINTENANCE.

Maintenance procedures for the 1163-4060 chassis are no different from those for the 1160-4060 (Section BA).

BB-2.1 ELECTRICAL CHECKS, OUTPUT AMPLIFIER.

Table BB-1 gives typical voltage measurements at the specified points in the amplifier circuit. These checks must be made with the normal complement of modules installed in the chassis.

TABLE BB-1

DC VOLTAGES FOR A PROPERLY FUNCTIONING OUTPUT AMPLIFIER (P/N 1163-4060)
(See Figure BB-5)

Stage	*Collector*	*Base*	*Emitter*
Q401	11.4	2.60	2.00
Q402	17.9	11.40	10.80
Q403	17.9	10.80	10.20
Q404	0	8.60	9.20

Notes: Unit operating with input connected (installed in chassis) output level fully CCW. Voltages measured with Type 1806-A direct (DC). These are typical readings; variations of ±10% are to be expected.

TABLES OF INTERCONNECTIONS

Top Deck	*Mating Connector*	*Mating Unit*
PL201	J101	Output Multiplier Mixer OMM-2 (Section FC)
PL202	J102	
PL203	J103	
PL204	J201	
PL205	J202	
PL206	J203	
PL207	J204	
PL207-N	J301	Digit Insertion Unit DI-1 (7 Installed) (Section DA)
PL208-N	J302	
PL209-N	J303	
PL210-N	J306	
PL211-N	J304	
PL212-N	J305	

Top Deck	*Mating Connector*	*Mating Unit*
PL213	J101	Cont. Adj. Decade CAD-1 (Section EA)
PL214	J403	
PL215	J402	
PL216	J404	
PL217	J102	
PL241	J202	Digit Insertion Unit DI-4 (Section DC)
PL242	J203	
PL207-1	J201	
SO201 (Terminals 1-6)	PL101	Calibrating Mixer CM-1 (Section EA)

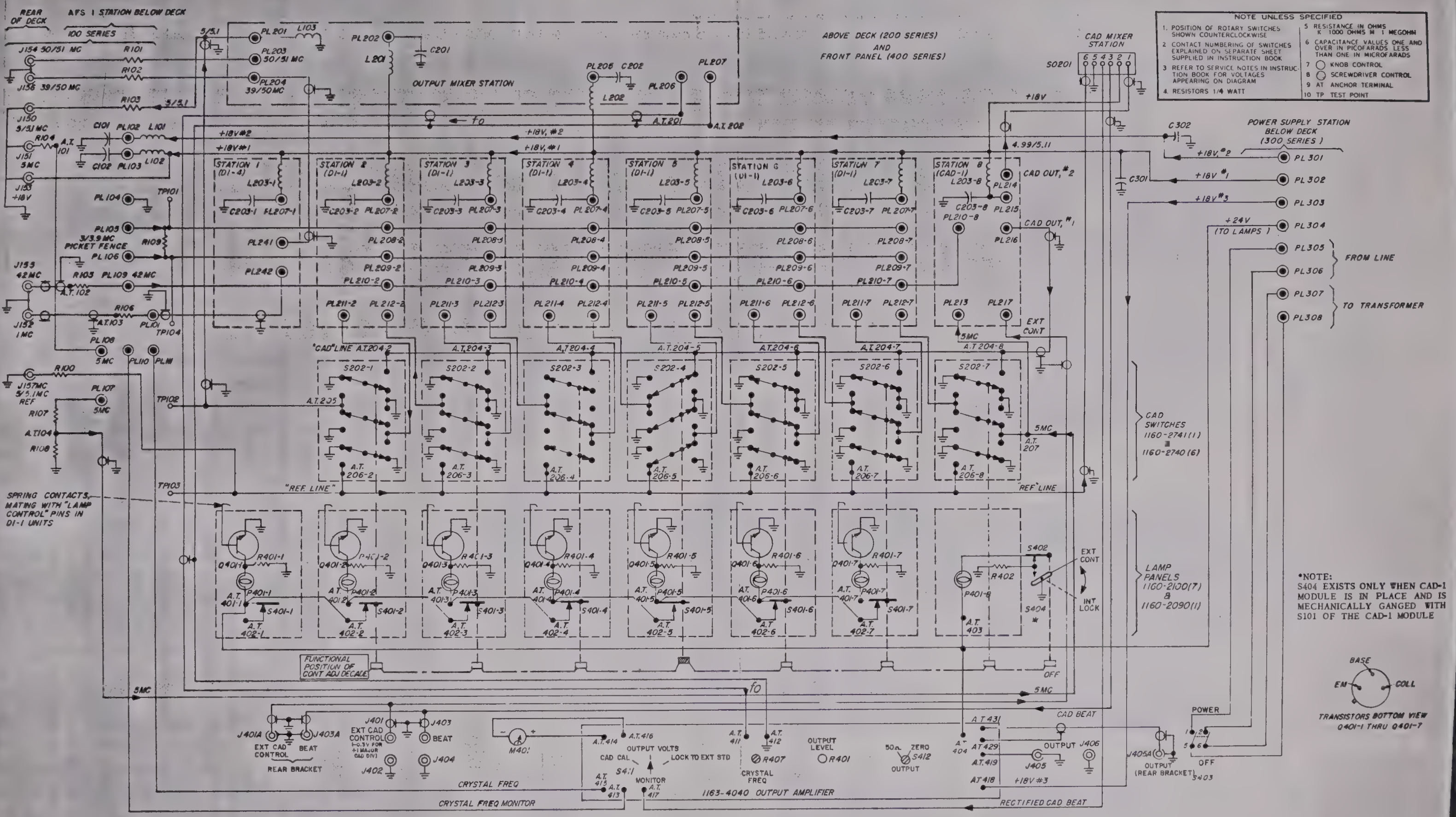
Bottom Deck	*Mating Connector*	*Mating Unit*
PL101	J201	Ancillary Frequency Source AFS (Section CA)
PL102	J202	
PL103	J105	
PL104	J204	
PL105	J205	
PL106	J203	
PL107	J106	
PL108	J104	
PL109	J301	
PL110	J103	
PL111	J101	

Bottom Deck	*Mating Connector*	*Mating Unit*
PL301	J506	Power Supply PS-1 (Section GA)
PL302	J507	
PL303	J508	
PL304	J505	
PL305	J501	
PL306	J503	
PL307	J502	
PL308	J504	

NOTE: The parts list appears on page BB-6.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS LESS THAN ONE IN MICROFARADS
7. ○ KNOB CONTROL
8. ○ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT


REAR OF DECK
AFS 1 STATION BELOW DECK
100 SERIES
J154 50/51 MC
J156 39/50 MC
J150 5/51 MC
J151 5MC
J153 +18V
J155 42MC
J152 1MC
J157MC 5/5.1MC REF
R101
R102
R103
R104
A.T. 101
C101
C102
PL102
PL103
L101
L102
5/5.1
PL104
PL105 3/3.9MC PICKET FENCE
PL106
R105
PL109 42MC
A.T. 102
R106
A.T.103
PL101
TP104
PL108 5MC
PL110
PL111
R100
PL107 5MC
R107
A.T.104
R108
TP101
TP102
TP103
SPRING CONTACTS, MATING WITH "LAMP CONTROL" PINS IN DI-1 UNITS
PL201
L103
PL203 50/51 MC
PL204 39/50MC
PL202
L201
C201
OUTPUT MIXER STATION
PL205
C202
L202
PL206
PL207
A.T.201
A.T.202
fo
+18V#2
+18V#1
+18V, #2
+18V, #1
ABOVE DECK (200 SERIES) AND FRONT PANEL (400 SERIES)
STATION 1 (DI-4)
STATION 2 (DI-1)
STATION 3 (DI-1)
STATION 4 (DI-1)
STATION 5 (DI-1)
STATION 6 (DI-1)
STATION 7 (DI-1)
STATION 8 (CAD-1)
L203-1
L203-2
L203-3
L203-4
L203-5
L203-6
L203-7
L203-8
C203-1
C203-2
C203-3
C203-4
C203-5
C203-6
C203-7
C203-8
PL207-1
PL207-2
PL207-3
PL207-4
PL207-5
PL207-6
PL207-7
PL241
PL242
PL208-2
PL208-3
PL208-4
PL208-5
PL208-6
PL208-7
PL209-2
PL209-3
PL209-4
PL209-5
PL209-6
PL209-7
PL210-2
PL210-3
PL210-4
PL210-5
PL210-6
PL210-7
PL210-8
PL211-2
PL212-2
PL211-3
PL212-3
PL211-4
PL212-4
PL211-5
PL212-5
PL211-6
PL212-6
PL211-7
PL212-7
PL213
PL214
PL215
PL216
PL217
CAD OUT, #2
CAD OUT, #1
EXT CONT
5MC
4.99/5.11
"CAD" LINE
A.T.204-2
A.T.204-3
A.T.204-4
A.T.204-5
A.T.204-6
A.T.204-7
A.T.204-8
A.T.205
S202-1
S202-2
S202-3
S202-4
S202-5
S202-6
S202-7
A.T. 206-2
A.T. 206-3
A.T. 206-4
A.T. 206-5
A.T. 206-6
A.T. 206-7
A.T. 206-8
A.T. 207
"REF. LINE"
REF LINE
CAD SWITCHES 1160-2741(1) & 1160-2740(6)
Q401-1
Q401-2
Q401-3
Q401-4
Q401-5
Q401-6
Q401-7
R401-1
R401-2
R401-3
R401-4
R401-5
R401-6
R401-7
P401-1
P401-2
P401-3
P401-4
P401-5
P401-6
P401-7
P401-8
A.T. 401-1
A.T. 401-2
A.T. 401-3
A.T. 401-4
A.T. 401-5
A.T. 401-6
A.T. 401-7
S401-1
S401-2
S401-3
S401-4
S401-5
S401-6
S401-7
A.T. 402-1
A.T. 402-2
A.T. 402-3
A.T. 402-4
A.T. 402-5
A.T. 402-6
A.T. 402-7
A.T. 403
S402
R402
S404 *
EXT CONT
INT LOCK
LAMP PANELS 1160-2100(7) & 1160-2090(1)
FUNCTIONAL POSITION OF CONT ADJ DECALE
OFF
CAD MIXER STATION
SO201
6 5 4 3 2 1
+18V
C302
C301
POWER SUPPLY STATION BELOW DECK (300 SERIES)
+18V, #2
+18V #1
+18V #3
+24V (TO LAMPS)
PL301
PL302
PL303
PL304
PL305
PL306
PL307
PL308
FROM LINE
TO TRANSFORMER
J401A
J403A
EXT CAD CONTROL
BEAT
REAR BRACKET
J401
EXT CAD CONTROL (-0.3V FOR +1 MAJOR CAD DIV)
J403
BEAT
J402
J404
M401
CRYSTAL FREQ
CRYSTAL FREQ MONITOR
A.T.414
A.T.416
OUTPUT VOLTS
CAD CAL
LOCK TO EXT STD
S4:1
MONITOR
A.T. 415
A.T. 413
A.T. 417
A.T. 411
A.T. 412
R407
CRYSTAL FREQ
OUTPUT LEVEL
R401
50Ω ZERO
S412
OUTPUT
1163-4040 OUTPUT AMPLIFIER
A.T. 404
A.T 431
AT429
A.T.419
AT418
J405
J406
OUTPUT
+18V #3
CAD BEAT
RECTIFIED CAD BEAT
J405A
OUTPUT (REAR BRACKET)
S403
POWER
OFF
BASE
EM
COLL
TRANSISTORS BOTTOM VIEW Q401-1 THRU Q401-7

*NOTE:
S404 EXISTS ONLY WHEN CAD-1 MODULE IS IN PLACE AND IS MECHANICALLY GANGED WITH S101 OF THE CAD-1 MODULE

Figure BB-3.
Over-all schematic diagram for Main Frame Chassis 1163-4060.

PARTS LIST

CAPACITORS

REF NO	DESCRIPTION	PART NO
C101	Ceramic, 0.1 µF +80-20% 50 V	4403-4100
C102	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C201	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C202	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C203-1	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C203-2	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C203-3	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C203-4	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C203-5	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C203-6	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C203-7	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C203-8	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C301	Ceramic, 0.02 µF +80-20%	4402-3200
C302	Ceramic, 0.02 µF +80-20%	4402-3200

INDUCTORS

REF NO	DESCRIPTION	PART NO
L101	Choke, iron core, 22 µH ±10%	4300-6600
L102	Choke, iron core, 22 µH ±10%	4300-6600
L103	Choke, iron core, 22 µH ±10%	4300-2600
L201	Choke, iron core, 22 µH ±10%	4300-6600
L202	Choke, iron core, 22 µH ±10%	4300-6600
L203-1 through L203-8	Choke, iron core, 22 µH ±10%	4300-6600

JACKS

REF NO	DESCRIPTION	PART NO
J150 through J157	Coaxial, miniature, bulkhead jack, 10-32 thread	4260-1288
J401	Binding post, insulated	0939-9835
J402	Binding post	0938-9834
J403	Binding post, insulated	0938-9835
J404	Binding post	0938-9834
J405	GR874, coaxial, panel	0874-4504
J406	Banana, panel mount	0874-6690
J401A	Coaxial, type BNC, bulkhead jack	4230-2300
J403A	Coaxial, type BNC, bulkhead jack	4230-2300
J405A	Coaxial, type BNC, bulkhead jack	4230-2300

PLUGS

REF NO	DESCRIPTION	PART NO
PL101 through PL111	Banana, with special mount	1160-2120
PL201 through PL206	Banana, with special mount	1160-2120
PL207-1 through PL207-7	Banana, with special mount	1160-2120
PL208-2 through PL208-7	Banana, with special mount	1160-2120
PL209-2 through PL209-7	Banana, with special mount	1160-2120
PL210-2 through PL210-8	Banana, with special mount	1160-2120
PL211-2	Banana part of switch assembly	1160-2741
PL211-3 through PL211-7	Banana part of switch assembly	1160-2740

PLUGS (Cont)

REF NO	DESCRIPTION	PA[illegible].0
PL212-2 through PL212-7	Banana part of switch assembly	1160-2740
PL213	part of switch assembly	1160-2740
PL214 through PL217	Banana, with special mount	1160-2120
PL241	Banana, with special mount	1160-2120
PL242	Banana, with special mount	1160-2120
PL310 through PL308	Banana, with special mount	1160-2120

RESISTORS

REF NO	DESCRIPTION	PART NO
R100	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R101	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R102	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R103	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R104	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R105	Composition, 470Ω ±5% 1/4 W	6099-1475
R106	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R107	Composition, 180Ω ±5% 1/4 W	6099-1185
R108	Composition, 100Ω ±5% 1/4 W	6099-1105
R401-1 through R401-7	Composition, 1.5 kΩ ±5% 1/2 W	6100-2155
R402	Power, 470Ω ±5% 3 W	6680-1475

SWITCHES

REF NO	DESCRIPTION	PART NO
S202-1 through S202-7	Special rf assembly	1160-2740
S401-1 through S401-7	Lamp part of DI dial assembly	1160-2100
S402	Lamp part of CAD dial assembly	1160-2090
S403	Toggle, DPST	7910-1300

TRANSISTORS

REF NO	DESCRIPTION	PART NO
Q401-1 through Q401-7	Type 2N1304	8210-1304

CIRCUIT-BOARD ASSEMBLIES

REF NO	DESCRIPTION	PART NO
———	Lamp control (DI Station)	1160-2100
———	Lamp control (CAD Station)	1160-2090
———	Assembly, output amplifier, etched-circuit board	1163-4040

MISCELLANEOUS

REF NO	DESCRIPTION	PART NO
———	Knob, DI-4 control	1163-1300
———	Knob, DI-1 control	1160-1300
———	Knob, CAD control	1160-1310
———	Knob, pointer skirt	5530-0400
M401	Meter, edgewise, panel, 100-0-100 µA ±3% 461Ω ±20%	5730-1382
P401-1 through P401-8	Lamp, incandescent, #327	5580-0400
SO201	Connector, multiple	423[illegible]'06

PARTS LIST

OUTPUT AMPLIFIER

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C401	Electrolytic, 33μF ±20% 10 V	4450-5400
C402	Electrolytic, 47μF ±20% 6 V	4450-5500
C403	Electrolytic, 15μF ±20% 20 V	4450-5200
C404	Electrolytic, 220μF ±20% 10 V	1160-0410
C405	Electrolytic, 15μF ±20% 20 V	4450-5200
C406	Ceramic, 0.01μF +80-20% 50 V	4401-3100
	RESISTORS	
R401	Potentiometer, composition, 250Ω ±10%	6047-1259
R402	Composition, 47Ω ±5% 1/4 W	6099-0475
R403	Potentiometer, wire-wound, 20kΩ ±10%	6059-3209
R404	Composition, 330Ω ±5% 1/4 W	6099-1335
R405	Composition, 1kΩ ±5% 1/4 W	6099-2105
R406	Composition, 10kΩ ±5% 1/4 W	6099-3105
R407	Potentiometer, composition, 10kΩ ±10%	6020-0400
R408	Composition, 1.5kΩ ±5% 1/4 W	6099-2155
R409	Composition, 100Ω ±5% 1/4 W	6099-1105
R410	Composition, 220Ω ±5% 1/4 W	6099-1225
R411	Composition, 820Ω ±5% 1/4 W	6099-1825
R412	Composition, 47Ω ±5% 1/4 W	6099-0475
R413	Composition, 47Ω ±5% 1/4 W	6099-0475
R414	Potentiometer, wire-wound, 20kΩ ±10%	6059-3209
R415	Composition, 100kΩ ±5% 1/4 W	6099-4105
R416	Composition, 8.2kΩ ±5% 1/4 W	6099-2825
R417	Potentiometer, wire-wound, 5kΩ ±10%	6059-2509
R418	Composition, 10Ω ±5% 1/4 W	6099-0105
R419	Composition, 10Ω ±5% 1/4 W	6099-0105
R420	Composition, 51Ω ±5% 1/4 W	6099-0515
R421	Composition, 3.3kΩ ±5% 1/4 W	6099-2335
R422	Composition, 51Ω ±5% 1/4 W	6099-0515
	TRANSISTORS	
Q401	Type 2N918	8210-1066
Q402	Type 2N918	8210-1066
Q403	Type 2N2218	8210-1028
Q404	Type 2N2904	8210-1074
	MISCELLANEOUS	
CR401	Diode, semiconductor, type 1N994	6082-1017
L401	Inductor, choke, iron core, 2.7μH ±10%	4300-1300
S411	Switch, rotary, wafer	7890-3840
S412	Switch, rotary, wafer	7890-3850

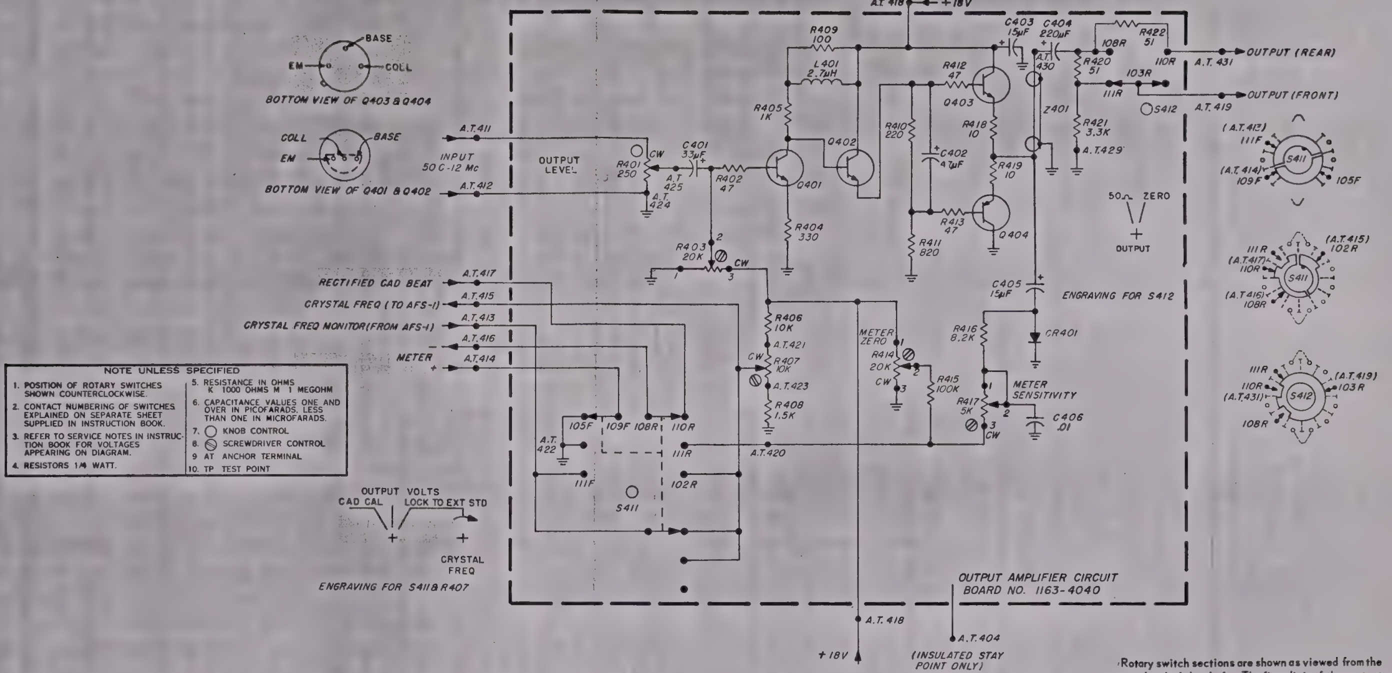

BASE
EM
COLL
BOTTOM VIEW OF Q403 & Q404
COLL
EM
BASE
BOTTOM VIEW OF Q401 & Q402
A.T.411
INPUT
50 C-12 Mc
A.T.412
RECTIFIED CAD BEAT
A.T.417
CRYSTAL FREQ (TO AFS-1)
A.T.415
CRYSTAL FREQ MONITOR (FROM AFS-1)
A.T.413
A.T.416
METER
A.T.414
NOTE UNLESS SPECIFIED
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT
OUTPUT VOLTS
CAD CAL
LOCK TO EXT STD
CRYSTAL FREQ
ENGRAVING FOR S411 & R407
OUTPUT LEVEL
R401 250
CW
A.T. 425
A.T. 424
C401 33µF
R402 47
R403 20K
R405 1K
R409 100
L401 2.7µH
Q401
Q402
R404 330
R410 220
C402 4.7µF
R411 820
R412 47
Q403
R418 10
R419 10
R413 47
Q404
A.T. 418
+18V
C403 15µF
C404 220µF
A.T. 430
Z401
R420 51
R421 3.3K
A.T.429
R422 51
108R
110R
103R
111R
S412
A.T. 431
OUTPUT (REAR)
A.T. 419
OUTPUT (FRONT)
50Ω ZERO
OUTPUT
C405 15µF
ENGRAVING FOR S412
CR401
R416 8.2K
METER SENSITIVITY
R417 5K
C406 .01
METER ZERO
R414 20K
R415 100K
R406 10K
A.T.421
R407 10K
A.T.423
R408 1.5K
A.T.420
105F
109F
108R
110R
111R
102R
111F
S411
A.T. 422
OUTPUT AMPLIFIER CIRCUIT BOARD NO. 1163-4040
A.T. 418
+18V
A.T.404
(INSULATED STAY POINT ONLY)
(A.T.412) 111F
(A.T.414) 109F
105F
S411
111R
(A.T.417) 110R
(A.T.416) 108R
(A.T.415) 102R
111R
110R
(A.T.431)
108R
(A.T.419) 103R
S412

Figure BB-5.
Schematic diagram for Output Amplifier 1163-4040.

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

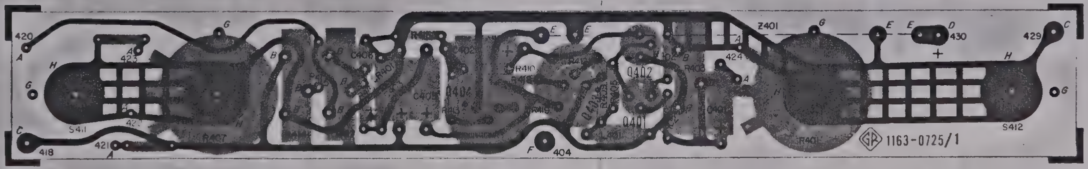

420
A
H
G
C
S411
418
421
A
423
F
404
E
E
Z401
G
424
0402
0401
R401
E
E
D
430
429
C
H
G
S412
1163-0725/1

Figure BB-4.
Etched Circuit assembly (P/N 1163-4040) for Output Amplifier.

NOTE: The number appearing on the foil side is not the part number.

SERVICE INSTRUCTIONS

section CA

ANCILLARY FREQUENCY SOURCE, AFS-1

P/N 1160-4010

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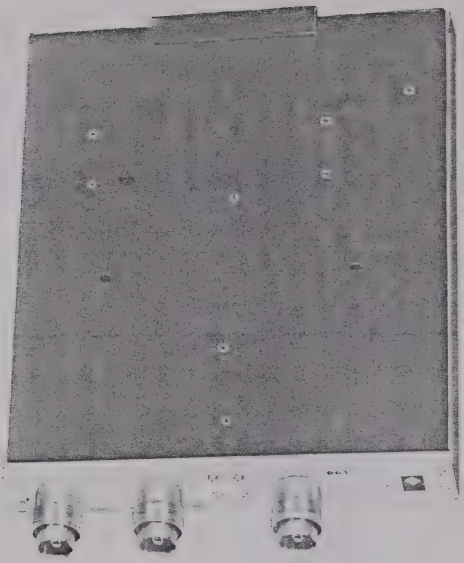
Form No. 1160-4010-A ID Number B140 February 1966

GENERAL RADIO COMPANY
West Concord, Massachusetts



Ancillary Frequency Source – AFS-1.

SECTION CA-1

INTRODUCTION

CA-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section is prepared from a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis".

Included in the following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension by experienced service personnel of the principles of operation. A trouble-analysis procedure that will aid in the isolation of defective circuits completes the section.

To facilitate part identification, reference designators used in the text and on the photographs are the same as those used on the complete schematic diagram and in the parts list. The reference designators are silk-screened on the module as a further aid in part location.

The service instructions rely on the use of an otherwise properly functioning synthesizer as a basic test frame for the suspect module. The instrument can be used to support the module in a convenient bench-service position and to supply it with power and test signals.

NOTE

First consideration should be given to the use of the wide spread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty coverage.

CA-1.2 PURPOSE.

The Ancillary Frequency Source (hereafter referred to as AFS) is the electrical starting point for all General Radio frequency synthesizers. Its purpose is to furnish the frequency reference for the entire instrument. The AFS accomplishes this either by the processing of an external signal for use as the reference frequency standard for the instrument, or by provision of an internal source for this reference, at the user's option. It also supplies a selected group of fixed frequencies, coherently derived from the reference, for use in, and (optionally) external to, the remainder of the frequency synthesizer.

The AFS module plugs into the lower section of the main sandwich deck, at the left-hand side of the instrument. It engages 11 banana plugs projecting from the sandwich deck. From these interconnections, power is applied to the AFS through 2 plugs and output signals are taken from the AFS through the remaining 9. Electrical ground connection is made by physical contact between the AFS and the sandwich, when the two large mounting screws are in place.

CA-1.3 DESCRIPTION.

CA-1.3.1 MECHANICAL LAYOUT.

The AFS module is an assembly of three etched-circuit boards that contain all of the electrical parts in the AFS circuitry. Along the perimeters of the etched boards are sheet-metal rails that provide electrical shielding and mechanical support for the entire assembly. The three boards are attached to each other and to the rear panel by machine screws.

The rear panel carries three GR874 connectors, two of which give access to fixed output frequencies – 5 Mc/s and 100 kc/s; the third is an input connector for an external lock signal (if used).

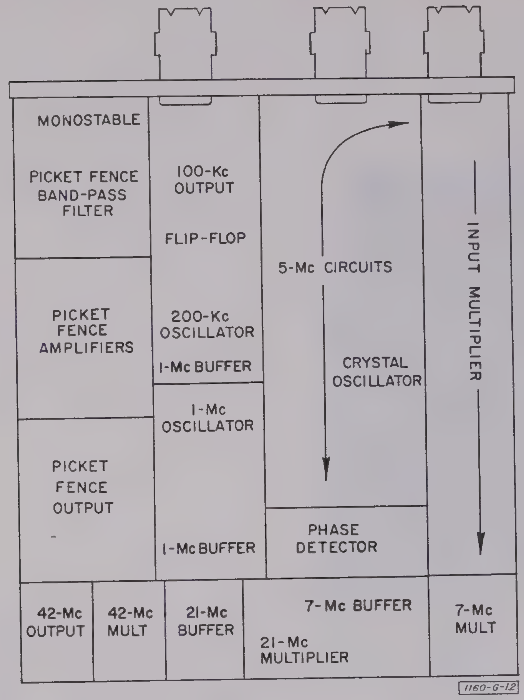

MONOSTABLE
PICKET FENCE BAND-PASS FILTER
100-Kc OUTPUT
FLIP-FLOP
5-Mc CIRCUITS
INPUT MULTIPLIER
PICKET FENCE AMPLIFIERS
200-Kc OSCILLATOR
1-Mc BUFFER
CRYSTAL OSCILLATOR
1-Mc OSCILLATOR
PICKET FENCE OUTPUT
1-Mc BUFFER
PHASE DETECTOR
42-Mc OUTPUT
42-Mc MULT
21-Mc BUFFER
7-Mc BUFFER
21-Mc MULTIPLIER
7-Mc MULT
1160-G-12

Figure CA-1.
Functional layout diagram for AFS-1 (viewed from component side).

A one-piece sheet-metal cover slides over the front of the module for electrical shielding, physical protection, and additional mechanical support. The internal adjustments are affected negligibly by the presence or absence of the cover; except for stray signal pickup, the AFS can function with or without it. Thus, alignment can be performed with the cover removed. When in place on the Main Frame assembly, the foil sides of the circuit boards face the sandwich deck and the detail parts are accessible for adjustment, if required in the service procedure.

The mounting screws for the unit are two 10-32 x 1-3/8-inch Phillips-head screws projecting through bushings near the centers of the two larger boards in the AFS. They screw into threaded inserts in the sandwich deck.

Interconnections between the etched boards are made by wire links on the foil side. A short length of miniature coaxial cable is also used and is soldered into eyelets on the etched boards.

Reference to the pictorial layout of Figure CA-1 shows the location of various circuits in the module; signal flow is also indicated. The circuits are divided and positioned to provide maximum isolation, logical signal flow, and minimum interconnection between etched boards.

CA-1.3.2 ELECTRICAL CHARACTERISTICS.

The AFS module contains the master oscillator, from which are derived all frequencies in the synthesizer (except for the free-running continuously adjustable oscillators in the CAD unit). Table CA-1 lists the outputs of the AFS unit. See the over-all schematic in Sections BA or BB for the interconnecting wiring by which the outputs are distributed throughout the synthesizer.

TABLE CA-1

DIRECT OUTPUT FREQUENCIES

Frequency	*Source*	*Available*	*Used by*	*Approximate Level*
5.0 Mc/s	Crystal Oscillator in AFS	J106	DI-1 (Station 7) CAD	1 V into 50Ω
		J104	Output Mixer Units	300 mV into 1 kΩ
		J108	For optional external use.	1 V behind 50Ω
1.0 Mc/s	Divided from 5.0 Mc/s	J201	DI-4 unit, when present	1 V into 1 kΩ
100 kc/s	Divided from 1 Mc/s	J206	For optional external use	1 V behind 50Ω
42 Mc/s	Multiplied from 1.0 Mc/s	J301	DI-1 units and CAD unit	1 V into 100Ω
Picket Fence 10 frequencies 100-kc spacing 3.0 – 3.9 Mc/s	Selected group of harmonics of 100 kc/s	J203 J204 J205	DI-1 units	400 mV into 7Ω per component

An input jack, J101, on the AFS module accepts a dc voltage from the front-panel potentiometer (R407) labeled CRYSTAL FREQ. This voltage is fed to a varactor diode in the crystal-oscillator circuit to control the crystal frequency by small amounts.

In addition, circuits are available in the AFS to lock the internal 5-Mc quartz oscillator to an equivalent (or superior) external standard. This feature allows any one of the several commonly available frequencies from standard-frequency-distribution systems to be fed into the synthesizer. Thus, the user can reference his synthesizer output to his own laboratory standard, or other equivalent laboratory instrument. Alternatively, the internally derived 5-Mc and the 100-kc signals are available from J108 and J206 to reference other instruments to the synthesizer.

The GR locking circuit will operate from any standard frequency from 100 kc/s to 5 Mc/s (with an amplitude between 0.25 and 5 volts, rms), provided that the frequency is an integral submultiple of 5 Mc/s. This signal must be fed into J107, a GR874 connector at the rear of the AFS unit, marked LOCK SIG IN. An automatic frequency multiplier chooses the harmonic number necessary to multiply the external reference frequency to 5 Mc/s. The resulting signal is fed to a phase detector, whose output signal locks the internal 5-Mc quartz oscillator to the external reference.

The CRYSTAL FREQ control mentioned above, when used with an external reference, can bring the internal crystal-oscillator frequency close enough to the external standard so that the quartz oscillator is captured and locked. The phase-detector error signal is brought out of the AFS (via J103) to deflect the front-panel monitor meter, when the MONITOR switch is set to LOCK TO EXT STD to show the condition of the phase lock.

SECTION CA-2

PRINCIPLES OF OPERATION

CA-2.1 GENERAL.

In this section, reference will be made to the schematic diagrams as noted: Figure CA-9 is the functional block diagram of the entire module, while the three etched-board diagrams are separate. Figure CA-10 shows the Master Frequency Section, Figure CA-11 the Picket-Fence Section, and Figure CA-12 the 42-Mc Multiplier Section.

NOTE

The figures are foldout diagrams at the end of this section.

In the elementary schematic diagram, the unit block diagram is seen divided into its three boards, with the circuits contained on each separated from one another.

CA-2.2 MASTER FREQUENCY SECTION (Figure CA-10).

The starting point of the system is the 5-Mc crystal oscillator stage, Q109. This circuit and all other 5-Mc circuits are on the Master Frequency Section board, one of the large boards (1160-0750/X). The circuit is a modified Clapp-Gouriet circuit with a varactor diode, CR104, representing part of the load capacitance of the AT-cut, hermetically sealed, room-temperature, quartz plate. A nominal 4 Vdc is supplied to the cathode of the varactor, through the phase detector, from the front-panel CRYSTAL FREQ control. When the phase detector is in operation, as described below, the dc-control voltage from the phase detector is added algebraically to the dc voltage fed in at J101, to keep the crystal-oscillator frequency equal to that of the input reference.

Q109 feeds a common-base, tuned buffer-amplifier, Q110. The output from Q110 is fed to the output jack, J104, which feeds the Output Mixer Module, OM in the Type 1161 synthesizer, and OMM-1 or OMM in the Type 1162 or 1163 synthesizers, respectively. Another output from the buffer feeds the amplifier, Q111, and emitter-follower, Q113. The emitter-follower output is adjustable (R152) to select the proper drive to Q114 and Q115, the high-level 5-Mc amplifiers. The Q114 amplifier feeds the input to the first DI-1 module in the synthesizer chain and the 5-Mc input to the CAD. The Q115 amplifier provides the 5-Mc signal to J108 for external use.

Q111, the common-emitter amplifier referred to above, feeds signals to the phase-detector drive amplifier, Q112, and the 1-Mc injection-locked oscillator on the Picket-Fence Section, described in paragraph CA-2.3. The push-pull side of the 5-Mc Phase Detector is driven by Q112. In the absence of a 5-Mc signal at the external-reference side of the phase detector (junction of the two diodes, CR105 and CR106), no dc voltage appears on the frequency-control line, except that present at J101.

The circuits associated with transistors Q101 through Q108 are part of the external-reference-frequency system described in paragraph CA-1.3.2. The input signal fed into J107 is clipped by the limiting diodes CR101 and CR102, if the level is more than about 1.2 volts, peak-to-peak. This signal is then fed to an amplifier, Q101, which drives the Schmitt circuit, Q102 and Q103.

The current pulse, developed by the Schmitt trigger from the zero crossings of the input signa is fed to the pulse shaper, comprised of L102 and C103 and resonant at approximately 5 Mc/s, and a shunt diode, CR103. The diode prevents the tuned circuit from resonating for more than one-half cycle of the LC resonant frequency. The resulting half-sine-wave pulse contains a strong 5-Mc component, which drives the normally-off pulse amplifier,Q104. The amplified pulse drives a double-tuned, critically coupled pair of 5-Mc tuned circuits, used to accentuate the 5-Mc signal and suppress unwanted sidebands.

This signal, with an envelope whose repetition rate is the same as the repetition rate of the frequency entering the LOCK SIG IN jack (J107), is used to drive the emitter-follower/Schmitt-trigger combination Q105, plus Q106 and Q107. The character of the signal output from the 5-Mc filter, L104 and L105, is such that there is always sufficient signal to operate the Schmitt circuit (without loss of any trigger pulses), even with input frequencies to J107 as low as 100 kc/s. Thus, the Schmitt circuit produces at its output a 5-Mc square wave independent of the level at the filter, and provides, thereby, a constant-level 5-Mc signal to drive Q108. The Q108 amplifier stage drives the diode side of the 5-Mc Phase Detector. Presence of this signal activates the phase detector and furnishes the feedback signal that controls the internal quartz oscillator.

CA-2.3 PICKET-FENCE SECTION (Figure CA-11).

The second large etched board in the AFS, called the Picket-Fence Section (1160-0760/X), contains all of the circuits required in generation of the picket-fence frequency band, plus the dividers to develop this frequency band proportionally from 5 Mc/s.

The division from 5 Mc/s to 1 Mc/s and from 1 Mc/s to 200 kc/s is accomplished through the use of oscillators injection-locked from the higher frequencies. The 200-kc to 100-kc division is effected by a simple flip-flop divider (Q207/Q208).

The 5-Mc signal from Q111 via T103, mentioned in paragraph CA-2.2, feeds a two-transistor injection-locked oscillator (Q201 and Q202). The circuit is an emitter-coupled, transistor-switch pair, so connected that only one transistor conducts at a time. A 1-Mc tank is in series with the collector of Q202. Part of the signal from this collector is fed to the base of Q201 (via C202), closing the loop on this oscillator circuit. The current waveforms in each transistor are square wave. Transistor Q201, loaded with resistor R201, gives a direct, independent square-wave voltage output. The base of Q202, which is not directly in the oscillator loop, accepts the 5-Mc voltage fed to it from the Q111/T103 amplifier (see Figure CA-9). It then locks this oscillator in a manner that makes its 1-Mc output exactly one-fifth of the 5-Mc signal being fed to it, by controlling the point at which the two transistors switch. The two outputs of this 1-Mc oscillator feed two amplifiers, Q203 and Q204, separately.

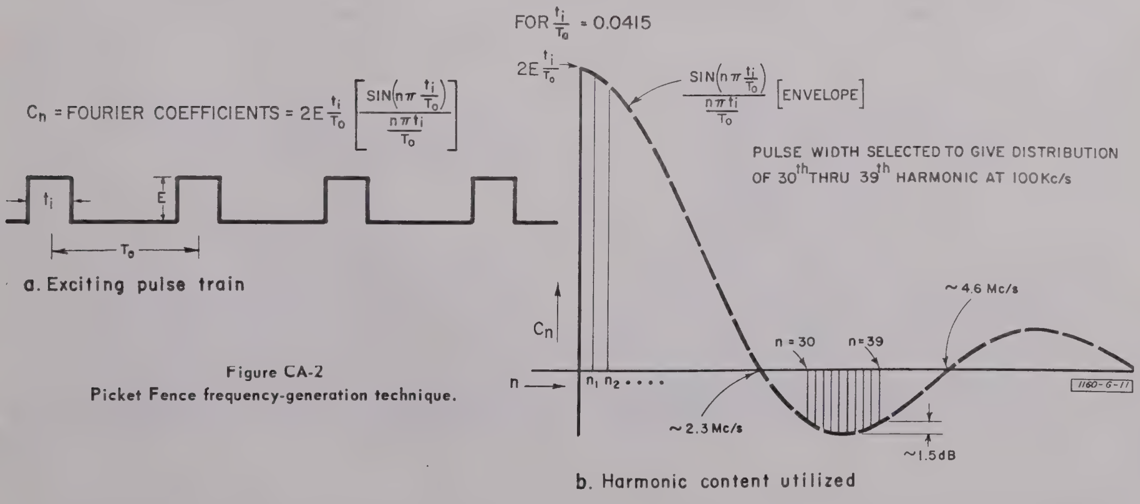
The Q204 amplifier, which operates from the square-wave output, isolates the 1-Mc oscillator (Q201 and Q202) from a similar 200-kc oscillator (Q205 and Q206). The action of this 200-kc oscillator is identical to the one described above, except that no sine-wave output is taken from it. The 200-kc square-wave output drives a flip-flop circuit (Q207 and Q208) whose two separate 100-kc outputs drive the remaining circuits on this board.

One of the outputs from the flip-flop feeds Q209, a tuned buffer which furnishes a 100-kc sine-wave output for external use. The other 100-kc output drives the picket-fence-forming circuit.

The core-element in the Picket-Fence Section is the monostable pulse generator, Q211 and Q212, driven by pulse amplifier Q201. In the circuits driven by this generator, the appropriate harmonics of 100 kc/s are enhanced, while some of the unwanted harmonics are suppressed.

The 100-kc rectangular-pulse train emanating from the pulse generator contains harmonics of 100 kc/s, which have an amplitude charateristic whose envelope is described by the $\frac{\sin x}{x}$ function.

The positions of the nulls depend on the ratio of t_i/T_o (see Figure CA-2). In the Picket-Fence gen-



C_n = FOURIER COEFFICIENTS = $2E\frac{t_i}{T_o}\left[\frac{\sin\left(n\pi\frac{t_i}{T_o}\right)}{\frac{n\pi t_i}{T_o}}\right]$
t_i
E
T_o
FOR $\frac{t_i}{T_o}$ = 0.0415
$2E\frac{t_i}{T_o}$
$\frac{\sin\left(n\pi\frac{t_i}{T_o}\right)}{\frac{n\pi t_i}{T_o}}$ [ENVELOPE]
PULSE WIDTH SELECTED TO GIVE DISTRIBUTION OF 30th THRU 39th HARMONIC AT 100Kc/s
C_n
n
n_1 n_2 • • • •
n = 30
n = 39
~4.6 Mc/s
~2.3 Mc/s
~1.5dB
1160-G-11

a. Exciting pulse train

b. Harmonic content utilized

Figure CA-2
Picket Fence frequency-generation technique.

erator, the t_i/T_0 duty ratio of the pulse is set to 0.0415, placing the first and second nulls of the $\frac{\sin x}{x}$ envelope at approximately 2.3 and 4.6 Mc/s, respectively. The pulse width is adjusted with C224, the time constant being determined primarily by C224, C225 and R241. When the pulse is adjusted to a width of 0.415 μs, the desired output band, 3.0 – 3.9 Mc/s, is centered in the second lobe of the response envelope, with the end pickets (3.0 and 3.9 Mc/s) drooping about 1.5 dB in amplitude below the center components.

The remaining selectivity in the Picket-Fence Section arises from two top-C coupled, tunable bandpass filters. The combined responses of these filters place two peaks near 3.0 and 3.9 Mc/s, with a 1.5-dB dip in the middle, to compensate for the peak in the output envelope of the pulse generator. The picket-fence circuit sequence is shown in Figure CA-9 to be the first filter T205/L204, followed by a buffer (Q213/Q214) with adjustable gain via R251. Then, a second filter, L205 and L206, is followed by a power-output stage that consists of an emitter-follower, Q215, a push-pull driver stage, Q216/Q217, and a push-pull output stage, Q218/Q219; all are transformer-coupled.

The balanced output goes to the PICKET-FENCE feed lines in the sandwich deck, via J203 and J205 into PL105 and PL106. J204, the center tap at the output transformer, is grounded in the sandwich deck via PL104.

CA-2.4 42-Mc SECTION (Figure CA-12).

The section of the AFS used to generate the 42-Mc signal is mounted on the small board (1160-0770/X). It is driven by the 1-Mc amplifier, Q203, mentioned previously in paragraph CA-2.3. The system consists of the following elements in order (see Figure CA-9). First, X7 transistor-multiplier, Q301, with 7-Mc tuned circuit L301, and a 7-Mc buffer with double-tuned, top-C coupled, bandpass filter, L302/L303. Next, a X3 multiplier produces 21 Mc/s, with T301 as the output tank followed by a 21-Mc buffer Q304/T302. A X2 multiplier, Q305/T303, multiplies the 21-Mc signal to 42 Mc/s and a 42-Mc output amplifier, Q306/T304, is the output stage.

SECTION CA-3

SERVICE AND MAINTENANCE

CA-3.1 GENERAL.

If the system trouble-analysis procedures of Section 5 at the front of the manual indicate possible malfunction of the AFS unit, the most positive verification of this suspicion is the substitution of another AFS module.

Since there is but one AFS module per instrument, and since service spares may not be available, it will not always be possible to make the substitution. However, selected tests, and most alignment procedures can be made in the field.

A thorough knowledge of the principles of the operation of this module is essential before service is attempted.

CA-3.2 TEST EQUIPMENT RECOMMENDED.

Table CA-2 lists the equipment recommended for service of the AFS modules. Equivalent equipment may be substituted.

CA-3.3 REMOVAL FROM CHASSIS.

CA-3.3.1 REMOVAL FROM CHASSIS.

Removal of the AFS is accomplished as follows:

a. Remove the synthesizer from the case; invert the instrument assembly.

b. Remove the two large screws that attach the AFS to the chassis.

c. Grasp the AFS module, by the GR874 connectors at the rear and the sheet metal grip at the front, and pull straight up.

CA-3.3.2 REMOVAL OF COVER.

Cover removal is accomplished as follows:

a. Remove the nine 4-40 screws in the bottom of the AFS, and the four from the top, to release the cover. The cover can then be slid forward, off the AFS unit.

b. Remount the open AFS on the Main Frame to provide loads and power for service and maintenance operation.

c. Reinstall the two large screws to hold the AFS down and make a positive ground-return connection between the AFS and the chassis.

NOTE

Electrical performance of the unit is not adversely affected by lack of the cover, except small signal leakages may degrade spurious performance of the synthesizer itself.

CA-3.3.3 REASSEMBLY.

Installation of the cover is the reverse of the above. Make sure that the cover, as it is installed, engages the spring fingers at the rear of the unit without interference. The cover goes between the lower lip of the rear panel and the contact fingers. The alignment tab on the left-hand end pan of the chassis will aid in the positioning of the AFS as it is installed in the chassis.

TABLE CA-2

TEST EQUIPMENT REQUIRED

Function	*Type Recommended*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806-A	2% accuracy; ac and dc capabilities
Oscilloscope	Tektronix Model 543 (with C/A plug-in and P6006, 10 × passive probe)	20 Mc/s, 0.5 V/cm with 8 pF (or less) probe capacitance
Frequency Standard	GR 1115-B	5-Mc and 100-kc outputs, accurate to at least 1×10^{-6}
Termination (50-ohm)	GR 874-W50BL	0.5% accuracy and GR874 connector
Digital Frequency Meter	GR 1153-A	Dc to 10 Mc/s; 0.1 V sensitivity, p-to-p
Standard Sweep-Frequency Generator	GR 1025-A	0.5% calibration accuracy
Patch Cord	GR 874-R22LA	Coaxial with GR874 connectors
Tuned Voltmeter	Sufficient selectivity to separate picket-fence components, spaced 100-kc/s apart from 3.0 to 3.9 Mc/s. A communications receiver with metered i-f output can be used with a signal generator to substitute for the measured quantity, to establish the picket-fence component amplitude.	

CA-3.4 TROUBLE ANALYSIS

CA-3.4.1 GENERAL.

Malfunction within an AFS module, as indicated by the system trouble-analysis procedures found in Section 5 at the front of the manual, can be isolated further here. The indications obtained from external connectors and test points on the synthesizer can be used to localize the difficulty to a particular circuit. In the procedures that follow, the shield cover must be removed from the AFS unit to permit access to interior test and adjustment points (refer to paragraph CA-3.3).

In the performance of these tests the synthesizer Main Frame chassis is used to support the AFS unit, and the other modules are used to power it and to supply loads for its outputs. All modules or bridging units should be in place.

With the case removed from the synthesizer and the AFS unit installed (less shield cover), the instrument can be operated upside down on the test bench. The readings are the same whether or not the cover is in place.

CA-3.4.2 POWER-SUPPLY INPUTS.

Measure power-supply input voltages first. Two power-supply input connections are made to the AFS, via J105 and J202 of the AFS; these voltages should be +18 ±0.2 V dc. If they are not in this range, tests should be made elsewhere in the system to correct this problem (refer to Sections BA, BB, and GA).

CA-3.4.3 EXTERNAL STANDARD INPUT CIRCUITS.

NOTE

> This circuitry is confined entirely to the AFS unit except for the front-panel control and monitor connections.

If the system does not lock, as indicated by the front-panel MONITOR meter, make sure that the free-running crystal-oscillator frequency is exactly 5 Mc/s, near the center of the range of the front-panel CRYSTAL FREQ control. Measure the frequency with the digital frequency meter connected to J108. If the frequency is not correct, set C122 so that 5 Mc/s occurs near the center of the CRYSTAL FREQ control range (refer to Table CA-5). If this does not clear up the difficulty, measure the dc voltage at J101, to determine that when R407, the CRYSTAL FREQ control is rotated, it affects the dc voltage at this point. Refer to Table CA-3 for the range of this adjustment. With no lock-signal input, the voltage at J103 should follow the CRYSTAL FREQ control and the voltage at J101.

When it has been determined that R407 is functioning normally, a 100-kc signal should be fed into the LOCK SIG IN JACK, J107, from the frequency

TABLE CA-3

OPERATING VOLTAGE SPECIFICATIONS
(See Figures CA-4 and CA-6)

INPUTS

Jack	*Description*	*Source/Load*	*Measure With*	*Measured Level*	*Frequency*
J105	Power Supply No. 1 Input	Internal	Dc VTVM	+18 V +0.2 V with respect to ground.	—
J202	Power Supply No. 2 Input	Internal	Dc VTVM	+18 V ±0.2 V with respect to ground.	—
J101	Crystal Frequency Control	Internal	Dc VTVM	≈+1.5 to +8.0 V dc. Nominally +4 V dc. Controlled from front panel of synthesizer.	—
J107 (Optional)	Lock-Signal Input	Frequency Standard	Ac VTVM	—	Any integral submultiple of 5 Mc/s — 100-kc/s to 5 Mc/s.

OUTPUTS

Jack	*Description*	*Source/Load*	*Measure With*	*Measured Level*	*Frequency*
J108	5-Mc Output	874-W50BL	Ac VTVM	0.7-1.0 V, rms	5.00 Mc/s ±20 c/s
J206	100-kc Output	874-W50BL	Ac VTVM	0.5-1.0 V, rms	100 kc/s
J104	5 Mc/s to Mixer	Internal	Ac VTVM	0.3 V, rms, ±10%	5.00 Mc/s
J106	5 Mc/s to Digits	Internal	Ac VTVM	1.0 V, rms, ±10%	5.00 Mc/s
J201	1-Mc Output	Internal	Ac VTVM	0.7-1.0 V, rms	1.00 Mc/s
J205	Picket-Fence Output	Internal	Tuned Voltmeter	0.4 V, rms,per component — 3.0-3.8, +10, -15% 3.9, +10, -20%	30, 31, 32.......39th harmonic of 100.0 kc/s
J301	42-Mc Output	Internal	Ac VTVM	1.0 V, rms, ±10%	42.00 Mc/s
J103	Crystal-Lock Monitor Output	Internal	Dc VTVM	Same as J101 above with no signal at J107. Error voltage of phase detector when dc signal at J107 is present.	

Notes:
Voltages measured in a properly operating and loaded AFS unit with input voltages supplied by syntheisizer.
The frequencies listed without tolerances are derived on a strict proportional basis from the 5-Mc standard. If an optional external standard is driving J107, the internal standard and all proportionally derived frequencies should be exactly proportional to the driving standard.

standard. Check the circuits from Q101 to Q108 with the procedures given in Table CA-5.

These checks should be sufficient to localize any malfunction in the multiplier to a single circuit. A check should also be made to ensure that a 5-Mc signal is being fed into the phase detector, through L110. If the circuit still fails to lock, check the line fed to the varactor CR104, through R125.

CA-3.4.4 5-Mc DISTRIBUTION CIRCUITS.

Several points in the system use a 5-Mc signal derived from different amplifiers in the AFS. These signals should be measured at various locations throughout the synthesizer to ascertain proper distribution. The 5-Mc signal should appear at J108 (rear of AFS), J151, the 5-Mc jack at rear of the chassis, and at the 5-Mc input to the CAD on the top of the deck (accessible when the CAD is removed). When the button under the CAD is depressed, the 5-Mc input signal to the CAD (PL213) is available at the "REF LINE" test point, TP103, on the left-hand end pan of the Main Frame chassis. It should be 300 mV, rms, ±10%, except J108 where it is 0.7 – 1.0 V, rms.

If any of these signals is absent, a check for shorts or opens in the system interconnecting wiring should be made (Section BA or BB). If no shorts or opens are present, the trouble lies in the AFS. The affected circuit can be found with the schematic diagrams and appropriate steps taken. The alignment procedure, Table CA-5, can be used as a guide.

CA-3.4.5 FREQUENCY DIVIDERS.

The three frequency dividers can be checked with oscilloscope Lissajous patterns. A 50:1 stationary pattern, formed between the 5-Mc (J108) and 100-kc (J206) outputs, on the rear apron of the AFS unit, should be obtained. If not, either the 1-Mc or 200-kc oscillator is not locked. If a Lissajous figure is set up between the 5-Mc and 1-Mc jacks at the rear of the sandwich deck (J152 in Types 1161, 1162, 1163 synthesizers) and a stationary 5:1 Lissajous is obtained, then the failure is in the 200-kc circuits. If the 5:1 pattern is not stationary, the 1-Mc oscillator is not locked. Similarly, a 10:1 Lissajous can be set up between 1-Mc and the 100-kc outputs. This will additionally check the 2-to-1 division by the flip-flop, Q207 and Q208. If any of these outputs is not present, check the stages involved (refer to Table CA-6).

If the 1-Mc signal is not present at the sandwich-deck receptacle, look for it at J201 on the AFS. It would be well also to make a continuity check of the chassis-jack circuits to make sure that a short or open circuit has not developed there (refer to Sections BA or BB).

CA-3.4.6 42-Mc CHECK.

The 42-Mc output feeding the DI-1 units and CAD is made available at the rear of the chassis (J155 for Types 1161, 1162 and 1163). This signal level can be measured with the electronic voltmeter.

If the signal is absent, check the 1-Mc signal at the rear of the sandwich (J152). If the 1-Mc signal is absent, the 1-Mc circuit should be restored to

(See Figure CA-6)

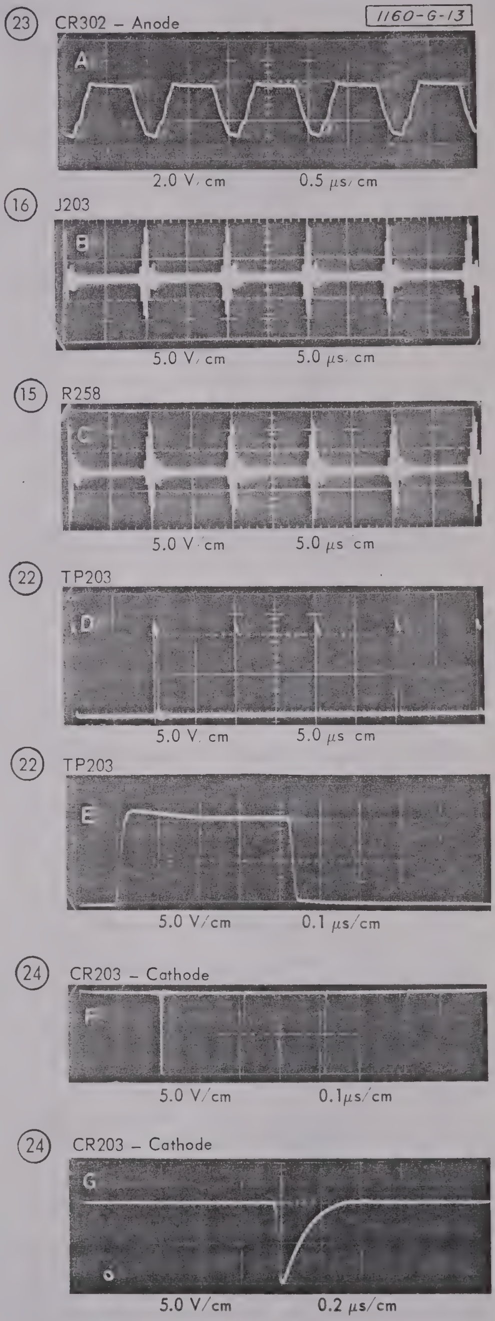


Figure CA-3. Trouble-analysis waveforms.

operation before further trouble analysis is attempted on the 42-Mc Section. If 1 Mc/s is present, check the waveform (Figure CA-3a) at the anode of CR302 to make sure that the X7 multiplier, Q301, is getting 1 Mc/s through the coaxial cable.

If the 42-Mc signal is absent, but the 1-Mc circuit appears to be operating properly, trouble analysis should center on the 42-Mc Section. This procedure can be done with reference to Table CA-7.

CA-3.4.7 PICKET-FENCE SECTION.

Operation of the Picket-Fence Section and distribution of its outputs can best be checked with an oscilloscope at the Main Frame test points labeled Picket Fence (TP101 in Type 1161/1162; TP101 and TP104 in Type 1163). They are mounted on the left-hand end pan of the chassis. The waveform here and at J205 on the AFS should be compared with Figure CA-3b for approximate shape and amplitude.

If the picket-fence signal is present, but indications in the system are that the Picket Fence Section is generating the wrong frequencies, check the dividers as in paragraph CA-3.4.5. If the picket-fence signal is absent completely, check for shorts in the Main Frame (Sections BA/BB) or in an individual DI-1 unit.

If the Picket-Fence Section supply busses are not shorted in the chassis, or in a DI-1 unit, the difficulty is in the AFS. The 100-kc output (J206) should be measured next (Table CA-3). If this output is absent, the trouble may be in the flip-flop divider Q207/Q208, or in the other dividers.

If the 100-kc signal is operative, check the pulse waveforms at Q211/Q212 (TP203) and then follow along the signal-flow path until the defective circuit is found (see Figure CA-3c-g). Refer to Table CA-6 for alignment details.

CAUTION

Normally, C224, R251 and the bandpass-filter tuning adjustments T205, L204, L205 and L206 should not be disturbed.

CA-3.5 ALIGNMENT PROCEDURES.

If the trouble-analysis procedures of paragraph CA-3.4 indicate marginal performance of a circuit function, or if repairs or replacements have been made, realignment of the many tuned circuits in the AFS unit may be required; Table CA-4 lists special tools recommended. Material in Tables CA-5 through CA-7 presents the alignment procedures. Typical waveforms to be looked for appear in Figures CA-5, CA-7, and CA-8. Figures CA-4 and CA-6 show test points and secondary-adjustment controls.

CA-3.6 REPAIRS AND REPLACEMENTS.

If subnormal circuits don't respond to adjustments indicated in the alignment procedures, use the schematic diagrams of Figures CA-10 through CA-12 to localize the trouble area and replace defective detail parts. The parts list at the end of this section gives pertinent descriptive information on parts used and reference designators appearing there are the same as those used on schematics and photos. In most cases, the designators are silk-screened on the etched-circuit board to complete the identification.

As an aid to isolate the defective part, Table CA-8 lists dc voltages at transistor leads in all stages of a properly functioning AFS unit. Basing diagrams for the transistor types used are given on the schematic diagrams. The collector lead is identified by a dot on the foil side of the etched-circuit boards.

TABLE CA-4

ALIGNMENT TOOLS RECOMMENDED

Type Adjustment	*Recommended Tool*
Ferrite cup-core inductors and transformers or Potentiometers	Any suitable screwdriver fitting the screw slot, or JFD #5284.
Ceramic Capacitors	Insulated screwdriver with minimum metallic contact with screw slot, e.g. JFD #5284.
Internally threaded ceramic coil with threaded, powdered-iron slug	Insulated soft-tip screwdriver. JFD #5284 may be used if care is taken not to damage brittle powdered iron.

NOTE: JFD = JFD Electronics Corporation, Brooklyn, New York.

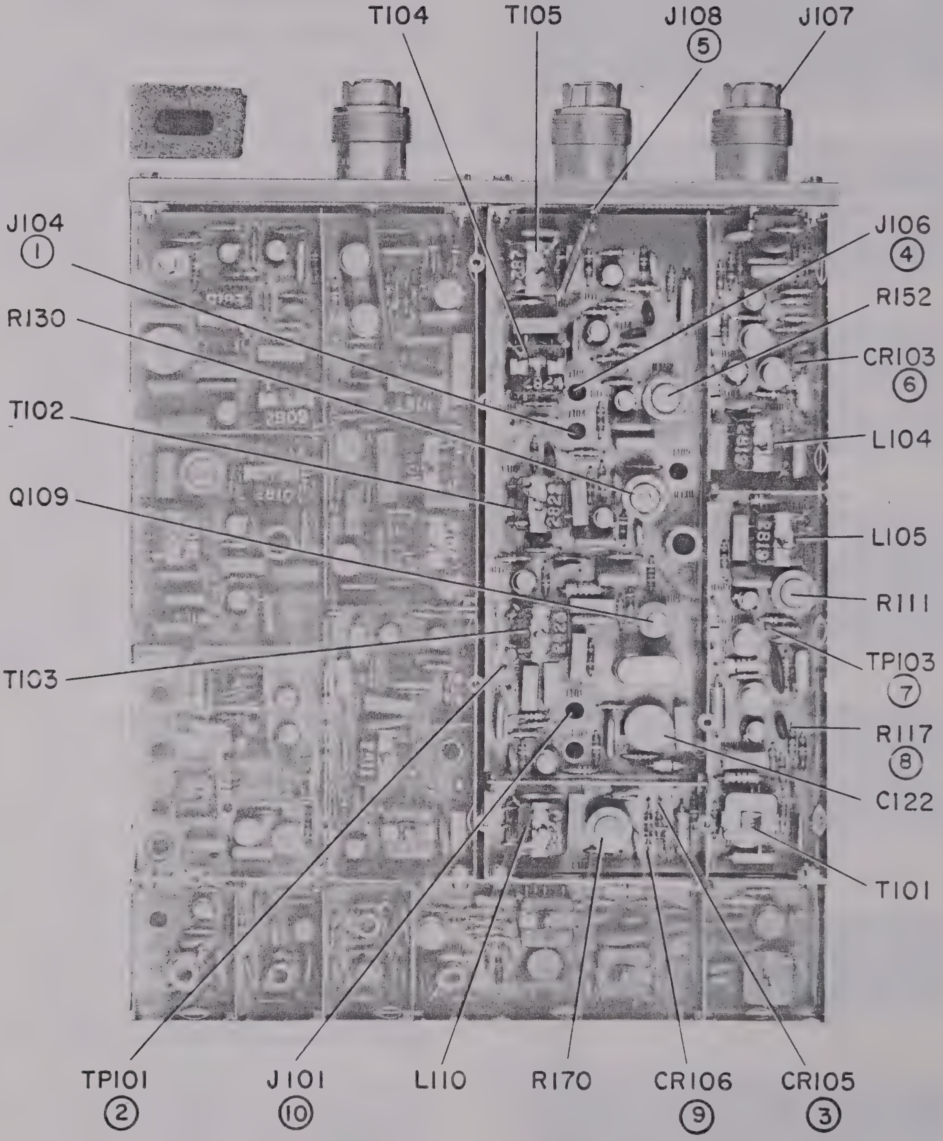

T104
T105
J108 ⑤
J107
J104 ①
J106 ④
R152
R130
CR103 ⑥
T102
L104
Q109
L105
R111
TP103 ⑦
T103
R117 ⑧
C122
T101
TP101 ②
J101 ⑩
L110
R170
CR106 ⑨
CR105 ③

Figure CA-4.
Master Frequency Section – test points and alignment controls.

TABLE CA-5

CIRCUIT ALIGNMENT CHECK CHART
MASTER FREQUENCY SECTION (Figures CA-4 and CA-5).

Circuit	*Test Point*	*Instrument*	*Alignment Procedures*
5-Mc buffer tuning	J104 ①	V	Adjust T102 for maximum 5 Mc/s.
5-Mc output	J104 ①	V	Adjust R130 for 300 m V, rms.
5-Mc amplifier tuning	TP101 ②	O	Adjust T103 for maximum at 5 Mc/s.
5-Mc amplifier tuning	CR105 (Anode) ③	O	Adjust L110 for maximum at 5 Mc/s.
5-Mc amplifier tuning	J106 ④	V	Adjust T104 for maximum 5 Mc/s.
5-Mc amplifier tuning	J106 ④	V	Adjust R152 for 1 V, rms, 5 Mc/s.
5-Mc ext output tuning	J108 ⑤	V	Adjust T105 for maximum 5-Mc sinewave.
Input Schmitt-trigger	CR103 (Cathode) ⑥	O	Remove Q109 (stops crystal oscillator). Inject standard 100-kc, 0.2-5.0 V, rms, signal at J107 and observe waveform, Fig. CA-5 (a). Inject standard 5-Mc, 0.2-5.0 V, rms, signal at J107 and observe waveform of Fig. CA-5 (b).
5-Mc bandpass filter	TP103 ⑦	O	Retain 5-Mc input at J107 and adjust L104 and L105 for maximum at 5 Mc/s; Fig. CA-5 (c). Reinject 100 kc/s at J107; slightly retouch L104 and L105 for minimum envelope dip, as in Figure CA-5 (d).
Schmitt-trigger trip point	R117/Q107 ⑧	O	Adjust R111 for continuous triggering with 100 kc/s at J107; see Figure CA-5 (f).
5-Mc drive to phase detector (reference side)	CR106 (Anode) ⑨	O	Adjust T101 for maximum 5 Mc/s with 100 kc/s or 5 Mc/s at J107.
Phase-detector balance	Front-panel MONITOR meter	—	Reinsert Q109. Remove standard signals. Adjust R170 to center meter with S411 (front-panel) in LOCK TO EXT STD position.
Coarse CRYSTAL FREQ trim	J101 ⑩	V	Adjust CRYSTAL FREQ (R407 front-panel control) to read 4 V dc.
	J108	C	Adjust C122 for 5.0 Mc/s ±5 c/s with non-metallic screwdriver.
Phase lock	Front-panel MONITOR meter	—	Inject standard 5 Mc/s, 0.2-5.0 V, rms, signal at J107. Slowly turn CRYSTAL FREQ control (R407 on front panel) back and forth and observe that meter follows this movement smoothly, to confirm that internal oscillator is locked to external standard. Repeat at 100 kc/s.

NOTES: The loop formed in the part lead serves as the test point. Instrument: O = Oscilloscope; V = VTVM; C = Counter. Probes required.

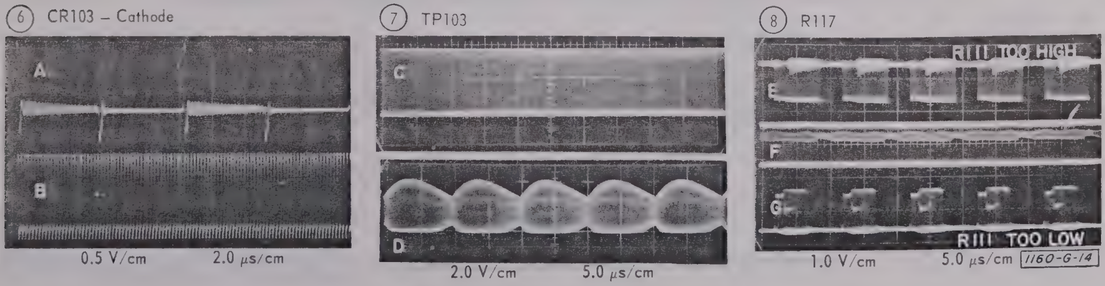


Figure CA-5. Master Frequency Section alignment waveforms.

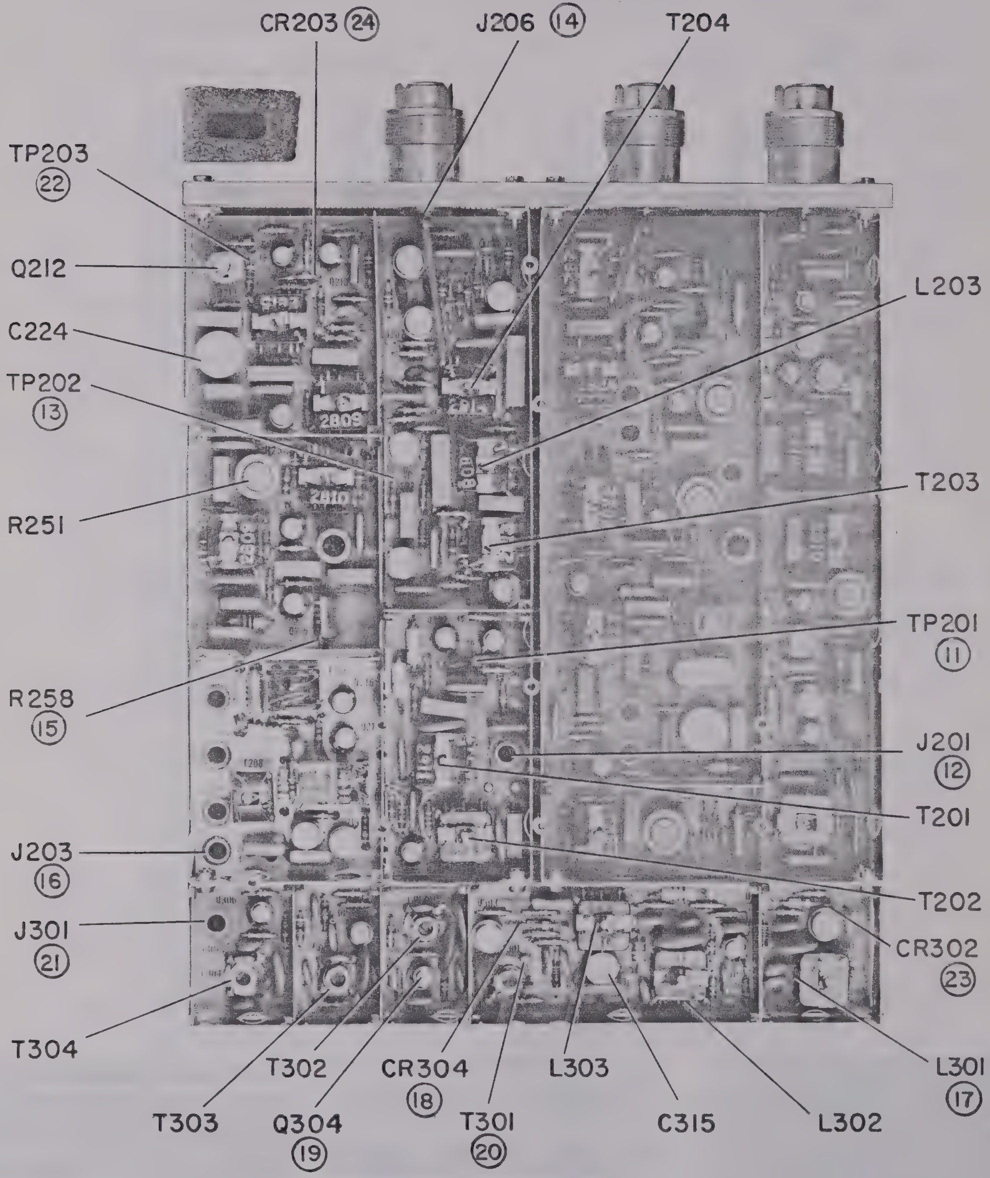

CR203 ㉔
J206 ⑭
T204
TP203 ㉒
Q212
L203
C224
TP202 ⑬
T203
R251
TP201 ⑪
R258 ⑮
J201 ⑫
T201
J203 ⑯
T202
J301 ㉑
CR302 ㉓
T304
T302
CR304 ⑱
L303
L301 ⑰
T303
Q304 ⑲
T301 ⑳
C315
L302

Figure CA-6.
Picket Fence and 42-MC Sections – test points and alignment controls.

TABLE CA-6

CIRCUIT ALIGNMENT CHECK CHART
PICKET FENCE SECTION (Figures CA-6 and CA-7)

Circuit	*Test Point*	*Instrument*	*Alignment Procedures*
1-Mc oscillator tuning	TP201 ⑪	O	Adjust T201 for lock; waveforms in Figure CA-7 (a and b).
1-Mc amplifier tuning	J201 ⑫	V	Adjust T202 for maximum at 1 Mc/s
1-Mc buffer tuning	TP202 ⑬	O	Adjust T203 for maximum at 1 Mc/s; see Figure CA-7 (c and d).
200-kc oscillator tuning	TP202 ⑬	O	Adjust L203 for lock; waveforms in Figure CA-7 (c and d).
100-kc ext. output	J206 ⑭	V	Adjust T204 for maximum at 100 kc/s
Bandpass filters (3.0-3.9 Mc)	(either end of R258) ⑮	O	Remove Q212. Drive C-terminal Q212 (TP203). Sweep 2.4—4.8-Mc range. Swept response as in Figure CA-7 (e).
Picket-Fence level symmetry	J203, J205 ⑯	T	Reinstall Q212. Adjust picket fence per Table CA-3. C224 tilts picket fence; R251 adjusts over-all levels.

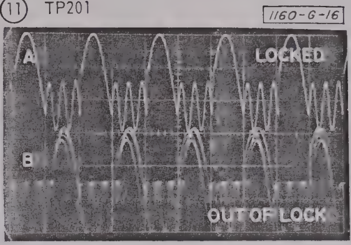
TABLE CA-7

CIRCUIT ALIGNMENT CHECK CHART
42-MC SECTION (Figures CA-6 and CA-8)

Circuit	*Test Point*	*Instrument*	*Alignment Procedures*
7-Mc multiplier tuning	L301, pin 2 ⑰	O	Adjust L301 for maximum at 7 Mc/s, Figure CA-8 (a).
7-Mc amplifier bandpass-filter tuning	Anode CR304 ⑱	O	Adjust L302/L303 for largest amplitude, Figure CA-8 (b).
21-Mc multiplier drive	Q304 (case) ⑲	O	Adjust C315 for 5 V, peak.
21-Mc multiplier tuning	T301, pin 3 ⑳	O	Adjust T301 for maximum at 21 Mc/s. Reset if necessary; see Fig. CA-8 (c).
21-Mc amplifier tuning	J301 ㉑	V	Tune T302 for maximum at 42 Mc/s.
42-Mc multiplier tuning	J301 ㉑	V	Tune T303 for maximum at 42 Mc/s.
42-Mc amplifier tuning	J301 ㉑	V	Tune T304 for maximum at 42 Mc/s.

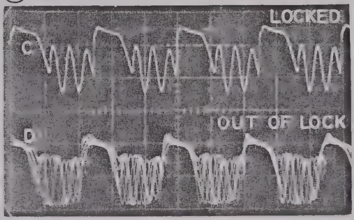
NOTES: Loop in part lead forms test points. Probes required.
Instrument: O = Oscilloscope, V = VTVM, T = Tuned Voltmeter.

⑪ TP201



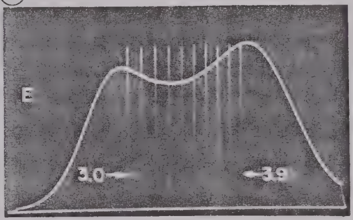
1.0 V/cm 0.5 μs/cm

⑬ TP202



1.0 V/cm 2.0 μs/cm

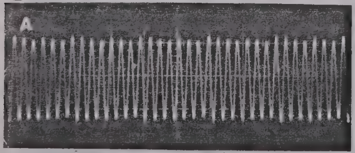
⑮ R258



Multiple Exposure – Swept Response

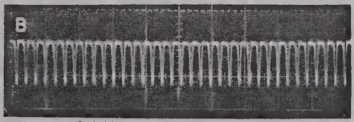
Figure CA-7.
Picket Fence Section alignment waveforms.

⑰ L301, pin 2



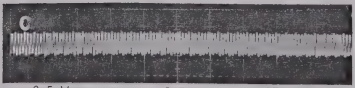
2.0 V/cm 0.5 μs/cm

⑱ CR304 – Anode



2.0 V/cm 0.5 μs/cm

⑳ T301, pin 3



0.5 V/cm 0.5 μs/cm

Figure CA-8.
42-Mc Section alignment waveforms.

TABLE CA-8

DC VOLTAGES – AFS-1

Transistor	*Emitter*	*Base*	*Collector*
Q101	4.5	3.8	2.0
Q102	2-2.5	2.0	1.0-1.5
Q103	2-2.5	2-2.5	0
Q104	0	0	17.5
Q105	2.0	2-3	17.5
Q106	2-2.5	2.0	1.0-1.5
Q107	2-2.5	2-2.5	0-1.2
Q108	9	9.7	17.5
Q109	1.3	1.05	0
Q110	8.8	9.5	17.5
Q111	13.4	13.5	0
Q112	12.7	15.5	0
Q113	8.4	8.5	17.5
Q114	8.0	8.8	17.0
Q115	8.0	8.8	17.0
Q201	11.0	10.5	15.0
Q202	11.0	10.5	15.0
Q203	4.0	4.6	15.5
Q204	15.0	15.1	0
Q205	12.0	12.1	16.0
Q206	12.0	12.1	15.0
Q207	13.8	14.5	7.5
Q208	13.8	14.5	7.5
Q209	1.7	1.8	17.5
Q210	0.05	–	16.0
Q211	4.6	4.5	16.0
Q212	4.6	6.0	6.0
Q213	4.4	4.1	0
Q214	3.7	4.4	17.0
Q215	8.2	8.8	17.5
Q216	0.1	–	17.8
Q217	0.1	–	17.8
Q218	0.1	–	17.8
Q219	0.1	–	17.8
Q301	6.5	7.0	0
Q302	11.2	12.5	17
Q303	6.8	7.0	0
Q304	7.5	8.1	17
Q305	8.3	8.3	0
Q306	9.0	9.7	17

NOTES:
1. AFS plugged into fully equipped Type 1163-A7C.
2. No input lock signal and no loads on 5-Mc and 100-kc outputs.
3. All measurements made with Type 1806-A (direct-no probe).
4. Allow ±10% tolerance for all readings.

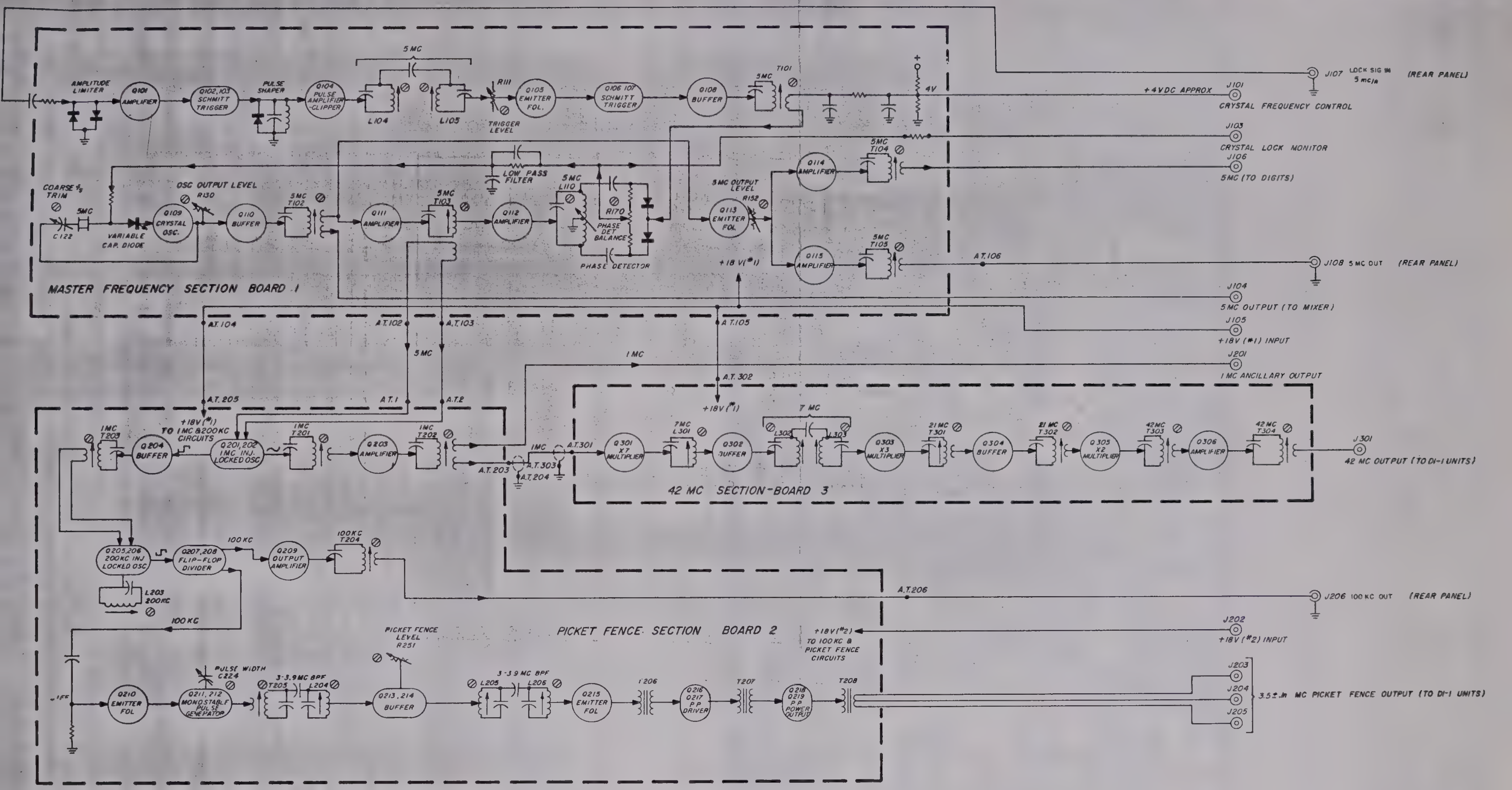
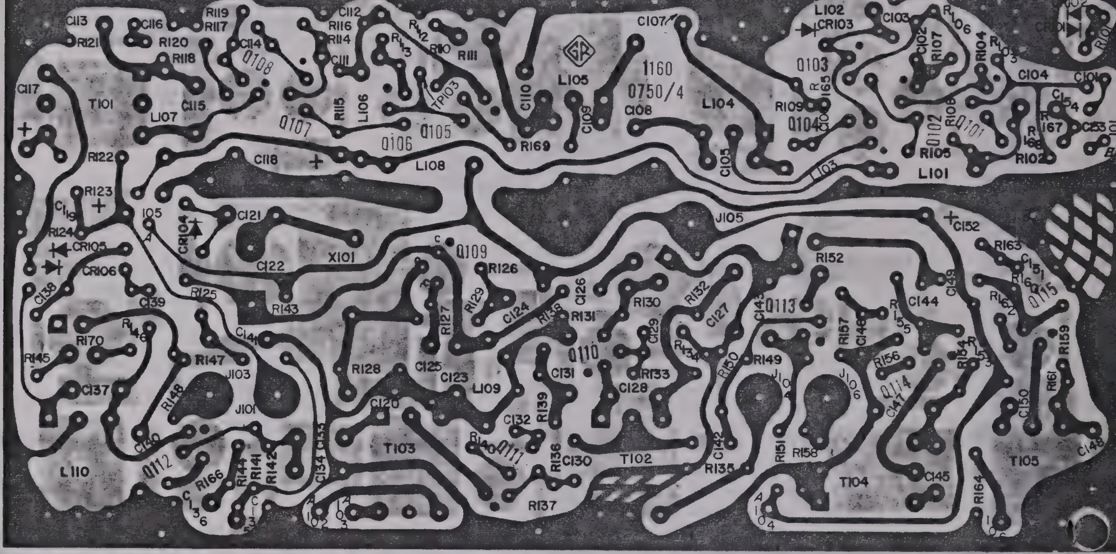

AMPLITUDE LIMITER
Q101 AMPLIFIER
Q102,103 SCHMITT TRIGGER
PULSE SHAPER
Q104 PULSE AMPLIFIER -CLIPPER
5 MC
L104
L105
R111
TRIGGER LEVEL
Q105 EMITTER FOL.
Q106 107 SCHMITT TRIGGER
Q108 BUFFER
5MC
T101
4V
+4VDC APPROX
J101
CRYSTAL FREQUENCY CONTROL
J107 LOCK SIG IN 5 mc/s
(REAR PANEL)
J103
CRYSTAL LOCK MONITOR
J106
5MC (TO DIGITS)
COARSE ⅛ TRIM
5MC
C122
VARIABLE CAP. DIODE
OSC OUTPUT LEVEL
R130
Q109 CRYSTAL OSC.
Q110 BUFFER
5MC T102
Q111 AMPLIFIER
5MC T103
Q112 AMPLIFIER
LOW PASS FILTER
5MC L110
R170
PHASE DET BALANCE
PHASE DETECTOR
5MC OUTPUT LEVEL
R152
Q113 EMITTER FOL
+18 V(#1)
Q114 AMPLIFIER
5MC T104
Q115 AMPLIFIER
5MC T105
A.T.106
J108 5 MC OUT
(REAR PANEL)
MASTER FREQUENCY SECTION BOARD 1
J104
5MC OUTPUT (TO MIXER)
J105
+18V (#1) INPUT
A.T.104
A.T.102
A.T.103
A.T.105
5 MC
1 MC
J201
1 MC ANCILLARY OUTPUT
A.T.302
A.T.205
A.T.1
A.T.2
+18V (#1)
TO 1MC & 200KC CIRCUITS
1MC T203
Q204 BUFFER
Q201,202 1MC INJ. LOCKED OSC
1MC T201
Q203 AMPLIFIER
1MC T202
A.T.203
1MC
A.T.303
A.T.204
A.T.301
+18V (#1)
7 MC
Q301 X7 MULTIPLIER
7MC L301
Q302 BUFFER
L302
L303
Q303 X3 MULTIPLIER
21MC T301
Q304 BUFFER
21 MC T302
Q305 X2 MULTIPLIER
42MC T303
Q306 AMPLIFIER
42 MC T304
J301
42 MC OUTPUT (TO DI-1 UNITS)
42 MC SECTION-BOARD 3
Q205,206 200KC INJ LOCKED OSC
Q207,208 FLIP-FLOP DIVIDER
100 KC
Q209 OUTPUT AMPLIFIER
100KC T204
L203 200KC
100 KC
A.T.206
J206 100 KC OUT
(REAR PANEL)
PICKET FENCE SECTION BOARD 2
+18V(#2)
TO 100KC & PICKET FENCE CIRCUITS
J202
+18V (#2) INPUT
PICKET FENCE LEVEL R251
PULSE WIDTH C224
-1FF
Q210 EMITTER FOL
Q211,212 MONOSTABLE PULSE GENERATOR
3-3.9MC BPF
T205
L204
Q213,214 BUFFER
3-3.9 MC BPF
L205
L206
Q215 EMITTER FOL
T206
Q216 Q217 PP DRIVER
T207
Q218 Q219 PP POWER OUTPUT
T208
J203
J204
J205
3.5±.1n MC PICKET FENCE OUTPUT (TO DI-1 UNITS)

Figure CA-9.
Elementary schematic diagram for Ancillary Frequency Source – AFS-1.


C113
R121
C116
R119
R117
R120
R118
C112
R116
R114
C111
Q108
C114
R110
R111
TP103
R115
L106
Q107
Q106
Q105
C107
1160
0750/4
C108
L105
C110
C109
L104
R169
C105
L103
L102
CR103
C103
Q103
R109
Q104
R163
C102
R107
R106
R104
R103
Q102
Q101
R108
R105
L101
C104
C101
C154
R167
C153
R168
R102
CR101
C117
T101
L107
C115
R122
C118
L108
R123
C119
R124
105
CR104
C121
X101
CR105
CR106
C122
R125
R143
C138
C139
Q109
R126
R127
R129
C124
R138
C126
R131
R130
R132
C127
J105
C152
R152
C143
Q113
C149
C144
R163
C151
R160
R162
Q115
R170
R146
R145
C141
R147
J103
C137
R148
J101
R128
C125
C123
L109
Q110
C131
C129
R134
R133
C128
R150
R149
J104
J106
R157
C146
R155
R156
Q114
R154
R153
R159
R161
C150
C147
C120
C132
R139
C142
R151
R158
C148
C140
Q112
R166
R144
R141
R142
C134
C133
T103
R140
Q111
R136
C130
T102
R135
T104
C145
R164
T105
L110
C136
C135
102
103
R137
104
106

Master Frequency Circuit etched-board assembly (P/N 1160-2750).

NOTE: The number appearing on the foil side is not the part number.

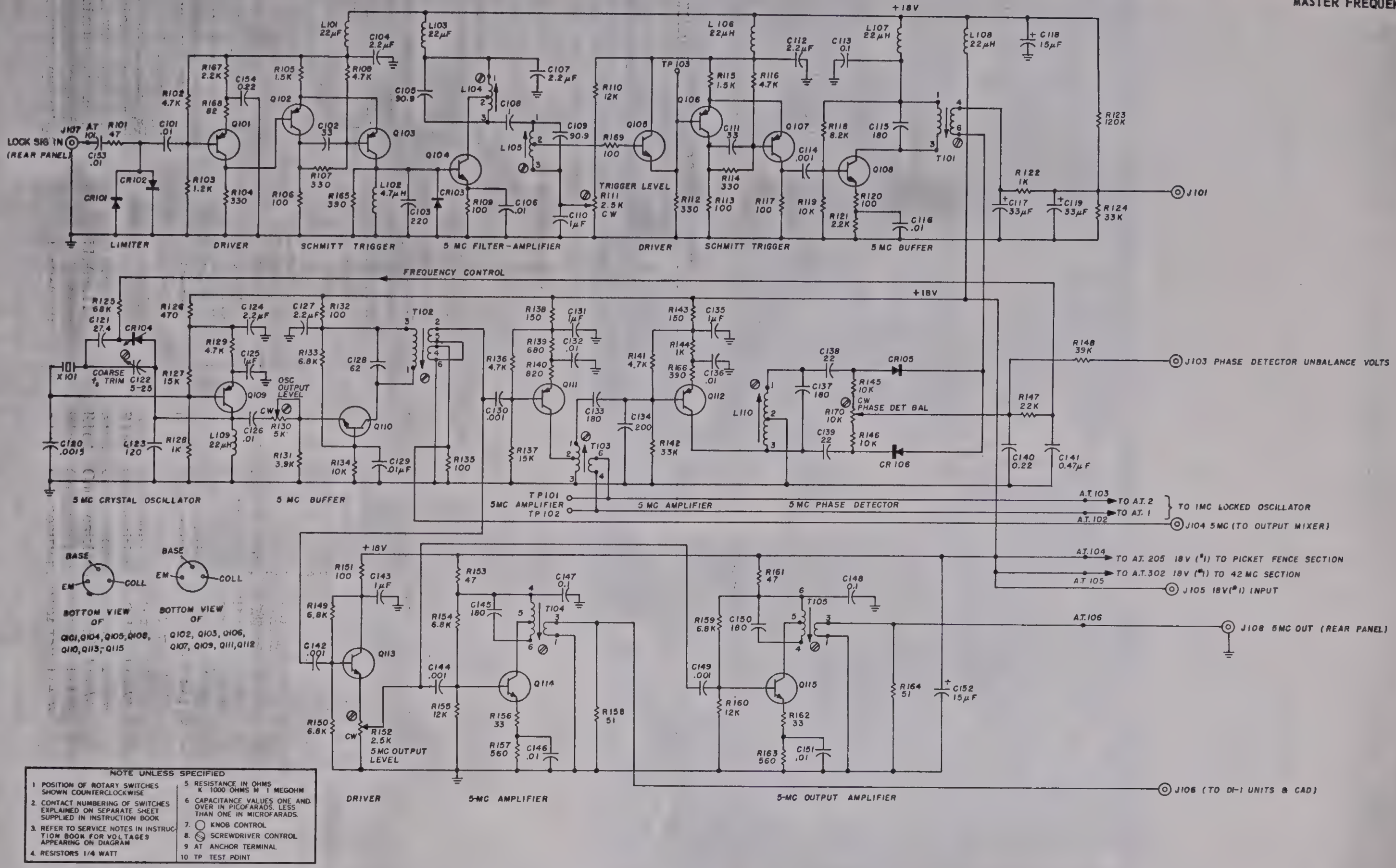
PARTS LIST

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C101	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C102	Ceramic, 33 pF ±5% 500 V (N750)	4417-0335
C103	Ceramic, 220 pF ±10% 500 V	4404-1228
C104	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C105	Mica, 90.9 pF ±2% 500 V	4700-0390
C106	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C107	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C108	Ceramic, 1 pF ±10% 500 V	4400-0100
C109	Mica, 90.9 pF ±2% 500 V	4700-0390
C110	Ceramic, 1 µF ±20% 25 V	4400-2070
C111	Ceramic, 33 pF ±5% 500 V (NPO)	4410-0335
C112	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C113	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C114	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C115	Mica, 180 pF ±5% 500 V	4700-0650
C116	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C117	Electrolytic, 33 µF ±20% 10 V	4450-5400
C118	Electrolytic, 15 µF ±20% 20 V	4450-5200
C119	Electrolytic, 33 µF ±20% 10 V	4450-5400
C120	Mica, 0.0015 µF ±5% 100 V	4700-0690
C121	Mica, 27.4 pF ±2% 500 V	4700-0236
C122	Trimmer, 5 to 25 pF	4910-1150
C123	Mica, 120 pF ±5% 500 V	4700-0426
C124	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C125	Ceramic, 1 µF ±20% 25 V	4400-2070
C126	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C127	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C128	Mica, 62 pF ±5% 500 V	4700-0364
C129	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C130	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C131	Ceramic, 1 µF ±20% 25 V	4400-2070
C132	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C133	Mica, 180 pF ±5% 500 V	4700-0650
C134	Mica, 200 pF ±5% 500 V	4700-0507
C135	Ceramic, 1 µF ±20% 25 V	4400-2070
C136	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C137	Mica, 180 pF ±5% 500 V	4700-0650
C138	Ceramic, 22 pF ±5% 500 V (NPO)	4410-0225
C139	Ceramic, 22 pF ±5% 500 V (NPO)	4410-0225
C140	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C141	Ceramic, 0.47 µF ±20% 25 V	4400-2054
C142	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C143	Ceramic, 1 µF ±20% 25 V	4400-2070
C144	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C145	Mica, 180 pF ±5% 500 V	4700-0650
C146	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C147	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C148	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C149	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C150	Mica, 180 pF ±5% 500 V	4700-0650
C151	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C152	Electrolytic, 15 µF ±20% 20 V	4450-5200
C153	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C154	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C201	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C202	Ceramic, 39 pF ±10% 500 V	4700-0307
C203	Ceramic, 1 µF ±20% 25 V	4400-2070
C204	Mica, 681 pF ±1% 300 V	4710-0681
C205	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C206	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C207	Mica, 562 pF ±1% 300 V	4710-0629
C208	Mica, 150 pF ±5% 500 V	4700-0441
C209	Ceramic, 0.1 µF ±20% 25 V	4400-2050
	CAPACITORS (Cont)	
C210	Ceramic, 1 µF ±20% 25 V	4400-2070
C211	Mica, 0.0036 µF ±5% 300 V	4580-3600
C212	Mica, 120 pF ±10% 500 V	4700-0425
C213	Ceramic, 1 µF ±20% 25 V	4400-2070
C214	Ceramic, 100 pF ±10% 500 V	4404-1108
C215	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C216	Ceramic, 100 pF ±10% 500 V	4404-1108
C217	Ceramic, 100 pF ±10% 500 V	4404-1108
C218	Ceramic, 0.47 µF ±20% 25 V	4400-2054
C219	Ceramic, 1 µF ±20% 25 V	4400-2070
C220	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C221	Mica, 0.0036 µF ±5% 300 V	4580-3600
C222	Ceramic, 15 pF ±5% 500 V (N750)	4417-0155
C223	Ceramic, 1 µF ±20% 25 V	4400-2070
C224	Trimmer, 5 to 25 pF	4910-1150
C225	Mica, 121 pF ±1% 500 V	4710-0031
C226	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C227	Mica, 36.5 pF ±2% 500 V	4700-0304
C228	Mica, 27.4 pF ±2% 500 V	4700-0236
C229	Mica, 36.5 pF ±2% 500 V	4700-0304
C230	Ceramic, 1 µF ±20% 25 V	4400-2070
C231	Ceramic, 1 µF ±20% 25 V	4400-2070
C232	Ceramic, 1 µF ±20% 25 V	4400-2070
C233	Mica, 27.4 pF ±2% 500 V	4700-0236
C234	Mica, 36.5 pF ±2% 500 V	4700-0304
C235	Mica, 33.2 pF ±2% 500 V	4700-0670
C236	Ceramic, 1 µF ±20% 25 V	4400-2070
C237	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C238	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C239	Ceramic, 1 µF ±20% 25 V	4400-2070
C240	Ceramic, 1 µF ±20% 25 V	4400-2070
C241	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C242	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C243	Ceramic, 2.2 µF ±20% 25 V	4400-2080
C244	Electrolytic, 15 µF ±20% 20 V	4450-5200
C245	Ceramic, 120 pF ±5% 500 V (N750)	4417-1125
C246	Ceramic, 150 pF ±5% 500 V (N750)	4417-1155
C301	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C302	Ceramic, 0.0047 µF +80-20% 500 V	4405-2479
C303	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C304	Ceramic, 15 pF ±5% 500 V (N750)	4417-0155
C305	Ceramic, 75 pF ±5% 500 V (N30)	4411-0753
C306	Ceramic, 22 pF ±5% 500 V (N750)	4417-0225
C307	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C308	Ceramic, 20 pF ±5% 500 V (N750)	4417-0205
C309	Ceramic, 100 pF ±5% 500 V (N30)	4411-1105
C310	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C311	Ceramic, 1.2 µF ±10% 500 V	4400-0129
C312	Ceramic, 20 pF ±5% 500 V (N750)	4417-0205
C313	Ceramic, 100 pF ±5% 500 V (N30)	4411-1105
C314	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C315	Trimmer, 2 to 8 pF 350 V	4910-2045
C316	Ceramic, 62 pF ±5% 500 V (N30)	4411-0625
C317	Ceramic, 15 pF ±5% 500 V (N30)	4411-0155
C318	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C319	Ceramic, 0.0047 µF +80-20% 500 V	4405-2479
C320	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C321	Ceramic, 91 pF ±5% 500 V (N30)	4411-0915
C322	Ceramic, 56 pF ±5% 500 V (N30)	4411-0565
C323	Ceramic, 0.0047 µF +80-20% 500 V	4405-2479
C324	Ceramic, 47 pF ±5% 500 V (N30)	4411-0475
C325	Ceramic, 22 pF ±5% 500 V (N30)	4411-0225
C326	Ceramic, 0.0047 µF +80-20% 500 V	4405-2479

PARTS LIST (Cont)

REF NO	DESCRIPTION	PART NO
	CAPACITORS (Cont)	
C327	Ceramic, 0.0047 µF +80-20% 500 V	4405-2479
C328	Ceramic, 0.0022 µF +80-20% 500 V	4404-2229
C329	Ceramic, 0.0022 µF +80-20% 500 V	4404-2229
C330	Ceramic, 0.0022 µF +80-20% 500 V	4404-2229
C331	Ceramic, 68 pF ±5% 500 V (N30)	4411-0685
C332	Ceramic, 15 pF ±5% 500 V (N30)	4411-0155
C333	Ceramic, 2.2 µF ±20% 25 V	4400-2080
	DIODES	
CR101	Semiconductor, type 1N3604	6082-1001
CR102	Semiconductor, type 1N3604	6082-1001
CR103	Semiconductor, type 1N995	6082-1002
CR104	Semiconductor, type 1N953	6084-1006
CR105	Semiconductor, type 1N191	6082-1008
CR106	Semiconductor, type 1N191	6082-1008
CR201	Semiconductor, type 1N118A	6082-1006
CR202	Semiconductor, type 1N118A	6082-1006
CR203	Semiconductor, type 1N3604	6082-1001
CR204	Semiconductor, type 1N3604	6082-1001
CR301	Semiconductor, type 1N957A	6083-1008
CR302	Semiconductor, type 1N995	6082-1002
CR303	Semiconductor, type 1N957A	6083-1008
CR304	Semiconductor, type 1N995	6082-1002
	INDUCTORS	
L101	Choke, iron core 22 µH ±10%	4300-2600
L102	Choke, iron core 4.7 µH ±10%	4300-1600
L103	Choke, iron core 22 µH ±10%	4300-2600
L104	Adjustable, ferrite cup	5000-2819
L105	Adjustable, ferrite cup	5000-2819
L106	Choke, iron core 22 µH ±10%	4300-2600
L107	Choke, iron core 22 µH ±10%	4300-2600
L108	Choke, iron core 22 µH ±10%	4300-2600
L109	Choke, iron core 22 µH ±10%	5000-2820
L110	Adjustable, ferrite cup	5000-2820
L201	Choke, iron core 33,000 µH ±5%	4300-6398
L202	Choke, iron core 33,000 µH ±5%	4300-6398
L203	Adjustable, ferrite cup	5000-2808
L204	Adjustable, ferrite cup	5000-2809
L205	Adjustable, ferrite cup	5000-2810
L206	Adjustable, ferrite cup	5000-2809
L207	Choke, iron core, 10 µH ±10%	4300-2200
L208	Choke, iron core, 5.6 µH ±10%	4300-1800
L209	Choke, iron core, 5.6 µH ±10%	4300-1800
L210	Choke, iron core, 5.6 µH ±10%	4300-1800
L301	Adjustable, ferrite cup	5000-2807
L302	Adjustable, ferrite cup	5000-2806
L303	Adjustable, ferrite cup	5000-2806
L304	Choke, iron core, 22 µH ±10%	5000-2820
	JACKS	
J101	Etched-circuit, eyelet type	1160-6110
J103	Etched-circuit, eyelet type	1160-6110
J104	Etched-circuit, eyelet type	1160-6110
J105	Etched-circuit, eyelet type	1160-6110
J106	Etched-circuit, eyelet type	1160-6110
J107	GR874, coaxial, panel, lug	0874-4260
J108	GR874, coaxial, panel, lug	0874-4260
J201	Etched-circuit, eyelet type	1160-6110
J202	Etched-circuit, eyelet type	1160-6110
J203	Etched-circuit, eyelet type	1160-6110
J204	Etched-circuit, eyelet type	1160-6110
J205	Etched-circuit, eyelet type	1160-6110
J206	GR874, coaxial, panel, lug	0874-4260
J301	Etched-circuit, eyelet type	1160-6110

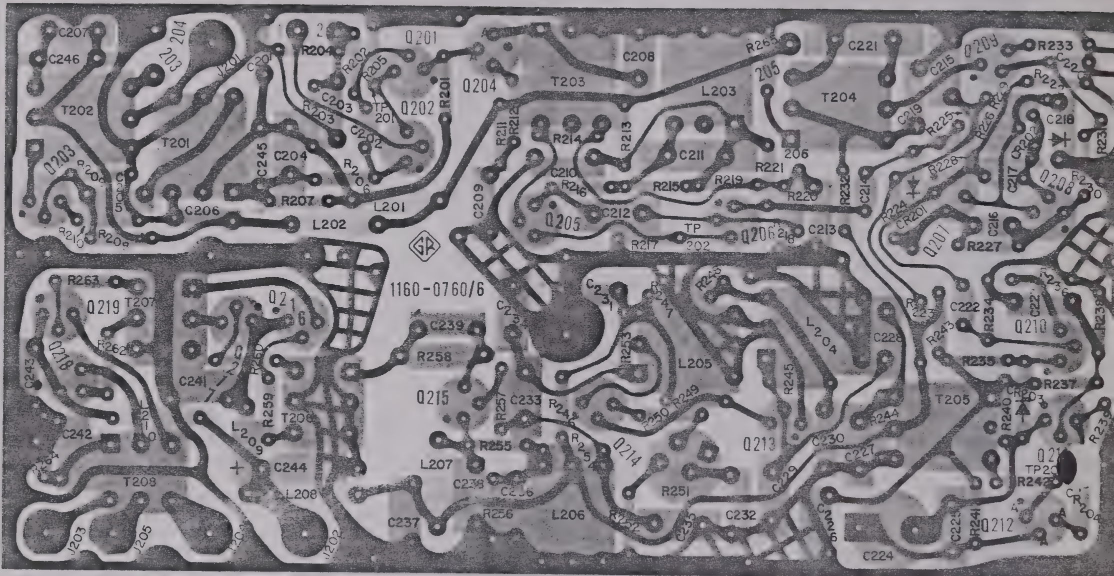
REF NO	DESCRIPTION	PART NO
	RESISTORS	
R101	Composition, 47Ω ±5% 1/4 W	6099-0475
R102	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R103	Composition, 1.2 kΩ ±5% 1/4 W	6099-2125
R104	Composition, 330Ω ±5% 1/4 W	6099-1335
R105	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R106	Composition, 100Ω ±5% 1/4 W	6099-1105
R107	Composition, 330Ω ±5% 1/4 W	6099-1335
R108	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R109	Composition, 100Ω ±5% 1/4 W	6099-1105
R110	Composition, 12 kΩ ±5% 1/4 W	6099-3125
R111	Potentiometer, composition, 2.5kΩ ±20% 1/4 W	6040-0500
R112	Composition, 330Ω ±5% 1/4 W	6099-1335
R113	Composition, 100Ω ±5% 1/4 W	6099-1105
R114	Composition, 330Ω ±5% 1/4 W	6099-1335
R115	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R116	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R117	Composition, 100Ω ±5% 1/4 W	6099-1105
R118	Composition, 8.2 kΩ ±5% 1/4 W	6099-2825
R119	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R120	Composition, 100Ω ±5% 1/4 W	6099-1105
R121	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R122	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R123	Composition, 120 kΩ ±5% 1/4 W	6099-4125
R124	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R125	Composition, 68 kΩ ±5% 1/4 W	6099-3685
R126	Composition, 470Ω ±5% 1/4 W	6099-1475
R127	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R128	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R129	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R130	Potentiometer, composition, 5 kΩ ±20%	6040-0600
R131	Composition, 3.9 kΩ ±5% 1/4 W	6099-2395
R132	Composition, 100Ω ±5% 1/4 W	6099-1105
R133	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R134	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R135	Composition, 100Ω ±5% 1/4 W	6099-1105
R136	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R137	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R138	Composition, 150Ω ±5% 1/4 W	6099-1155
R139	Composition, 680Ω ±5% 1/4 W	6099-1685
R140	Composition, 820Ω ±5% 1/4 W	6099-1825
R141	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R142	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R143	Composition, 150Ω ±5% 1/4 W	6099-1155
R144	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R145	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R146	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R147	Composition, 22 kΩ ±5% 1/4 W	6099-3225
R148	Composition, 39 kΩ ±5% 1/4 W	6099-3395
R149	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R150	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R151	Composition, 100Ω ±5% 1/4 W	6099-1105
R152	Potentiometer, composition, 2.5 kΩ ±20%	6040-0500
R153	Composition, 47Ω ±5% 1/4 W	6099-0475
R154	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R155	Composition, 12 kΩ ±5% 1/4 W	6099-3125
R156	Composition, 33Ω ±5% 1/4 W	6099-0335
R157	Composition, 560Ω ±5% 1/4 W	6099-1565
R158	Composition, 51Ω ±5% 1/4 W	6099-0515
R159	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R160	Composition, 12 kΩ ±5% 1/4 W	6099-3125
R161	Composition, 47Ω ±5% 1/4 W	6099-0475
R162	Composition, 33Ω ±5% 1/4 W	6099-0335
R163	Composition, 560Ω ±5% 1/4 W	6099-1565
R164	Composition, 51Ω ±5% 1/4 W	6099-0515
R165	Composition, 390Ω ±5% 1/4 W	6099-1395
R166	Composition, 390Ω ±5% 1/4 W	6099-1395


LOCK SIG IN
(REAR PANEL)
J107
AT 101
R101 47
C153 .01
C101 .01
CR101
CR102
R102 4.7K
R103 1.2K
R167 2.2K
R168 82
C154 0.22
Q101
R104 330
R105 1.5K
Q102
C102 33
R107 330
R106 100
Q103
R108 4.7K
L101 22μF
C104 2.2μF
R165 390
L102 4.7μH
C103 220
CR103
Q104
C105 90.9
L103 22μF
L104
C108
C107 2.2μF
L105
C109 90.9
R109 100
C106 .01
C110 1μF
R111 2.5K CW
TRIGGER LEVEL
R169 100
Q105
R110 12K
TP 103
R112 330
Q106
R115 1.5K
C111 33
R114 330
R113 100
L 106 22μH
R116 4.7K
Q107
C112 2.2μF
R117 100
C114 .001
R119 10K
C113 0.1
L107 22μH
R118 8.2K
C115 180
Q108
R120 100
R121 2.2K
C116 .01
T101
+18V
L108 22μH
C118 15μF
R122 1K
C117 33μF
C119 33μF
R123 120K
R124 33K
J101
LIMITER
DRIVER
SCHMITT TRIGGER
5 MC FILTER-AMPLIFIER
DRIVER
SCHMITT TRIGGER
5MC BUFFER
FREQUENCY CONTROL
+18V
R125 68K
C121 27.4
CR104
X101
COARSE fo TRIM
C122 5-25
R126 470
R127 15K
C120 .0015
C123 120
R128 1K
R129 4.7K
C124 2.2μF
C125 1μF
Q109
OSC OUTPUT LEVEL
CW
R130 5K
C126 .01
L109 22μH
R131 3.9K
C127 2.2μF
R132 100
R133 6.8K
C128 62
T102
Q110
R134 10K
C129 .01μF
R135 100
R136 4.7K
C130 .001
R138 150
C131 1μF
R139 680
C132 .01
R140 820
Q111
R137 15K
C133 180
T103
C134 200
R141 4.7K
R143 150
C135 1μF
R144 1K
R166 390
C136 .01
Q112
R142 33K
L110
C138 22
C137 180
C139 22
CR105
R145 10K
CW PHASE DET BAL
R170 10K
R146 10K
CR 106
R147 22K
C140 0.22
C141 0.47μF
R148 39K
J103 PHASE DETECTOR UNBALANCE VOLTS
5MC CRYSTAL OSCILLATOR
5 MC BUFFER
TP101
5MC AMPLIFIER
TP 102
5 MC AMPLIFIER
5 MC PHASE DETECTOR
A.T. 103
TO A.T. 2
TO A.T. 1
A.T. 102
TO IMC LOCKED OSCILLATOR
J104 5MC (TO OUTPUT MIXER)
A.T. 104
TO A.T. 205 18V (#1) TO PICKET FENCE SECTION
TO A.T. 302 18V (#1) TO 42 MC SECTION
A.T. 105
J105 18V(#1) INPUT
A.T. 106
J108 5MC OUT (REAR PANEL)
J106 (TO DI-I UNITS & CAD)
BASE
EM
COLL
BOTTOM VIEW OF
Q101, Q104, Q105, Q108, Q110, Q113, Q115
BASE
EM
COLL
BOTTOM VIEW OF
Q102, Q103, Q106, Q107, Q109, Q111, Q112
+18V
R151 100
C143 1μF
R149 6.8K
C142 .001
Q113
R150 6.8K
CW
R152 2.5K 5MC OUTPUT LEVEL
R153 47
C145 180
C147 0.1
T104
R154 6.8K
C144 .001
Q114
R155 12K
R156 33
R157 560
C146 .01
R158 51
R161 47
C148 0.1
T105
R159 6.8K
C150 180
C149 .001
Q115
R160 12K
R162 33
R163 560
C151 .01
R164 51
C152 15μF
DRIVER
5-MC AMPLIFIER
5-MC OUTPUT AMPLIFIER

NOTE UNLESS SPECIFIED

1 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS
K 1000 OHMS M 1 MEGOHM
6 CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9 AT ANCHOR TERMINAL
10 TP TEST POINT

Figure CA-10.
Schematic diagram for Master Frequency Section.


C207
C246
204
203
J201
T202
T201
Q203
R208
R210
R209
C205
C206
C201
R204
R202
R205
R203
C203
TP 201
Q201
Q202
R201
C202
C204
C245
R206
R207
L202
L201
Q204
T203
C208
R265
205
L203
C221
T204
R211
R212
R214
R213
C211
R221
206
R215
R219
R220
R232
C214
C210
R216
C212
Q205
C209
R217
TP 202
Q206
R218
C213
Q209
R233
C215
C219
R225
R226
R229
R222
C218
CR202
R228
C217
Q208
R230
R224
CR201
Q207
C216
R227
1160-0760/6
R263
Q219
T207
R262
Q218
C243
C241
R260
Q217
R259
T206
L209
L210
C242
R264
T208
C244
L208
J203
J205
J204
J202
C239
R258
Q215
R257
C233
C234
R255
L207
C238
C236
C237
R256
L206
R252
C235
R254
Q214
R246
R250
R249
C231
R247
R253
R248
L205
R245
L204
Q213
R251
C228
C230
C227
R244
C229
C232
C226
C224
R223
C222
R234
C220
Q210
R243
R235
R237
T205
CR203
R240
Q211
TP203
R242
R241
C223
Q212
CR204
R236
R238
R239
R231

Picket Fence Circuit etched-board assembly (P/N 1160-2761).

NOTE: The number appearing on the foil side is not the part number.

PARTS LIST (Cont)

RESISTORS (Cont)

REF NO	DESCRIPTION	PART NO
R167	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R168	Composition, 82Ω ±5% 1/4 W	6099-0825
R169	Composition, 100Ω ±5% 1/4 W	6099-1105
R170	Potentiometer, composition, 10 kΩ ±20%	6040-0700
R201	Composition, 270Ω ±5% 1/4 W	6099-1275
R202	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R203	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R204	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R205	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R206	Composition, 270Ω ±5% 1/4 W	6099-1275
R207	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R208	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R209	Composition, 680 kΩ ±5% 1/4 W	6099-1680
R210	Composition, 470Ω ±5% 1/4 W	6099-1475
R211	Composition, 220Ω ±5% 1/4 W	6099-1225
R212	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R213	Composition, 47Ω ±5% 1/4 W	6099-0475
R214	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R215	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R216	Composition, 270Ω ±5% 1/4 W	6099-1275
R217	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R218	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R219	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R220	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R221	Composition, 560Ω ±5% 1/4 W	6099-1565
R222	Composition, 910Ω ±5% 1/4 W	6099-1915
R223	Composition, 47Ω ±5% 1/4 W	6099-0475
R224	Composition, 20 kΩ ±5% 1/4 W	6099-3205
R225	Composition, 20 kΩ ±5% 1/4 W	6099-3205
R226	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R227	Composition, 12 kΩ ±5% 1/4 W	6099-3125
R228	Composition, 12 kΩ ±5% 1/4 W	6099-3125
R229	Composition, 220Ω ±5% 1/4 W	6099-1225
R230	Composition, 680Ω ±5% 1/4 W	6099-1680
R231	Composition, 220Ω ±5% 1/4 W	6099-1225
R232	Composition, 47Ω ±5% 1/4 W	6099-0475
R233	Composition, 390Ω ±5% 1/4 W	6099-1395
R234	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R235	Composition, 820Ω ±5% 1/4 W	6099-1825
R236	Composition, 330Ω ±5% 1/4 W	6099-1335
R237	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R238	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R239	Composition, 180Ω ±5% 1/4 W	6099-1185
R240	Composition, 560Ω ±5% 1/4 W	6099-1565
R241	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R242	Composition, 470Ω ±5% 1/4 W	6099-1475
R243	Composition, 47Ω ±5% 1/4 W	6099-0475
R244	Composition, 2.7 kΩ ±5% 1/4 W	6099-2275
R245	Composition, 2.7 kΩ ±5% 1/4 W	6099-2275
R246	Composition, 100Ω ±5% 1/4 W	6099-1105
R247	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R248	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R249	Composition, 3.9 kΩ ±5% 1/4 W	6099-2395
R250	Composition, 27Ω ±5% 1/4 W	6099-0275
R251	Potentiometer, composition, 100Ω ±20%	6040-0100
R252	Composition, 820Ω ±5% 1/4 W	6099-1825
R253	Composition, 2.7 kΩ ±5% 1/4 W	6099-2275
R254	Composition, 2.7 kΩ ±5% 1/4 W	6099-2275
R255	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R256	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R257	Composition, 47Ω ±5% 1/4 W	6099-0475
R258	Composition, 470Ω ±5% 1/2 W	6100-1475
R259	Composition, 10Ω ±5% 1/4 W	6099-0105
R260	Composition, 10Ω ±5% 1/4 W	6099-0105

RESISTORS (Cont)

REF NO	DESCRIPTION	PART NO
R261	Composition, 10Ω ±5% 1/4 W	6099-0105
R262	Composition, 10Ω ±5% 1/4 W	6099-0105
R263	Composition, 10Ω ±5% 1/4 W	6099-0105
R264	Composition, 4.7Ω ±5% 1/4 W	6099-9475
R265	Composition, 220Ω ±5% 1/4 W	6099-1225
R301	Composition, 1.8 kΩ ±5% 1/4 W	6099-2185
R302	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R303	Composition, 100Ω ±5% 1/4 W	6099-1105
R304	Composition, 2.7 kΩ ±5% 1/4 W	6099-2275
R305	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R306	Composition, 27 kΩ ±5% 1/4 W	6099-3275
R307	Composition, 100Ω ±5% 1/4 W	6099-1105
R308	Composition, 2.7 kΩ ±5% 1/4 W	6099-2275
R309	Composition, 1.8 kΩ ±5% 1/4 W	6099-2185
R310	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R311	Composition, 220Ω ±5% 1/4 W	6099-1225
R312	Composition, 1.8 kΩ ±5% 1/4 W	6099-2185
R313	Composition, 100Ω ±5% 1/4 W	
R314	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R315	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R316	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R317	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R318	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R319	Composition, 100Ω ±5% 1/4 W	6099-1105
R320	Composition, 33Ω ±5% 1/4 W	6099-0335
R321	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R322	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R323	Composition, 47Ω ±5% 1/4 W	6099-0475
R324	Composition, 820Ω ±5% 1/4 W	6099-1825
R325	Composition, 33Ω ±5% 1/4 W	6099-0335

TRANSFORMERS

REF NO	DESCRIPTION	PART NO
T101	Adjustable, ferrite cup	5000-2821
T102	Adjustable, ferrite cup	5000-2822
T103	Adjustable, ferrite cup	5000-2823
T104	Adjustable, ferrite cup	5000-2824
T105	Adjustable, ferrite cup	5000-2824
T201	Adjustable, ferrite cup	5000-2811
T202	Adjustable, ferrite cup	5000-2812
T203	Adjustable, ferrite cup	5000-2813
T204	Adjustable, ferrite cup	5000-2814
T205	Adjustable, ferrite cup	5000-2815
T206	Adjustable, ferrite cup	5000-2816
T207	Adjustable, ferrite cup	5000-2817
T208	Adjustable, ferrite cup	5000-2818
T301	Adjustable, ceramic, iron core	1160-2290
T302	Adjustable, ceramic, iron core	1160-2310
T303	Adjustable, ceramic, iron core	1160-2320
T304	Adjustable, ceramic, iron core	1160-2440

TRANSISTORS

REF NO	DESCRIPTION	PART NO
Q101	Type 2N3250	8210-1089
Q102	Type 2N1499A	8210-1499
Q103	Type 2N1499A	8210-1499
Q104	Type 2N708	8210-3089
Q105	Type 2N708	8210-3089
Q106	Type 2N1499A	8210-1499
Q107	Type 2N1499A	8210-1499
Q108	Type 2N708	8210-3089
Q109	Type 2N2188	8210-1045
Q110	Type 2N708	8210-3089
Q111	Type 2N2188	8210-1045
Q112	Type 2N2188	8210-1045

PARTS LIST (Cont)

TRANSISTORS (Cont)

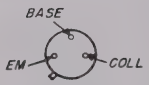
REF NO	DESCRIPTION	PART NO
Q113	Type 2N708	8210-3089
Q114	Type 2N708	8210-3089
Q115	Type 2N708	8210-3089
Q201	Type 2N708	8210-3089
Q202	Type 2N708	8210-3089
Q203	Type 2N708	8210-3089
Q204	Type 2N2188	8210-1045
Q205	Type 2N1304	8210-1304
Q206	Type 2N1304	8210-1304
Q207	Type 2N1499A	8210-1499
Q208	Type 2N1499A	8210-1499
Q209	Type 2N1304	8210-1304
Q210	Type 2N708	8210-3089
Q211	Type 2N2369	8210-1052
Q212	Type 2N2369	8210-1052
Q213	Type 2N2188	8210-1045
Q214	Type 2N708	8210-3089
Q215	Type 2N708	8210-3089
Q216	Type 2N708	8210-3089
Q217	Type 2N708	8210-3089

TRANSISTORS (Cont)

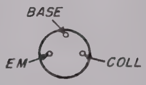
REF NO	DESCRIPTION	PART NO
Q218	Type 2N2218	8210-1028
Q219	Type 2N2218	8210-1028
Q301	Type 2N1499A	8210-1499
Q302	Type 2N708	8210-3089
Q303	Type 2N1499A	8210-1499
Q304	Type 2N708	8210-3089
Q305	Type 2N2188	8210-1045
Q306	Type 2N2188	8210-1045

MISCELLANEOUS

REF NO	DESCRIPTION	PART NO
X101	Crystal 5-Mc	1213-0440
—	Assembly, etched board Master Frequency	1160-2750
—	Assembly, etched board Picket Fence	1160-2761
—	Assembly, etched board 42-Mc circuit	1160-2770



BOTTOM VIEW
OF
Q201, Q202, Q203,
Q205, Q206, Q209 –
Q212, Q214 - Q219



BOTTOM VIEW
OF
Q204, Q207, Q208,
Q213

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS
   K = 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT = ANCHOR TERMINAL
10. TP = TEST POINT

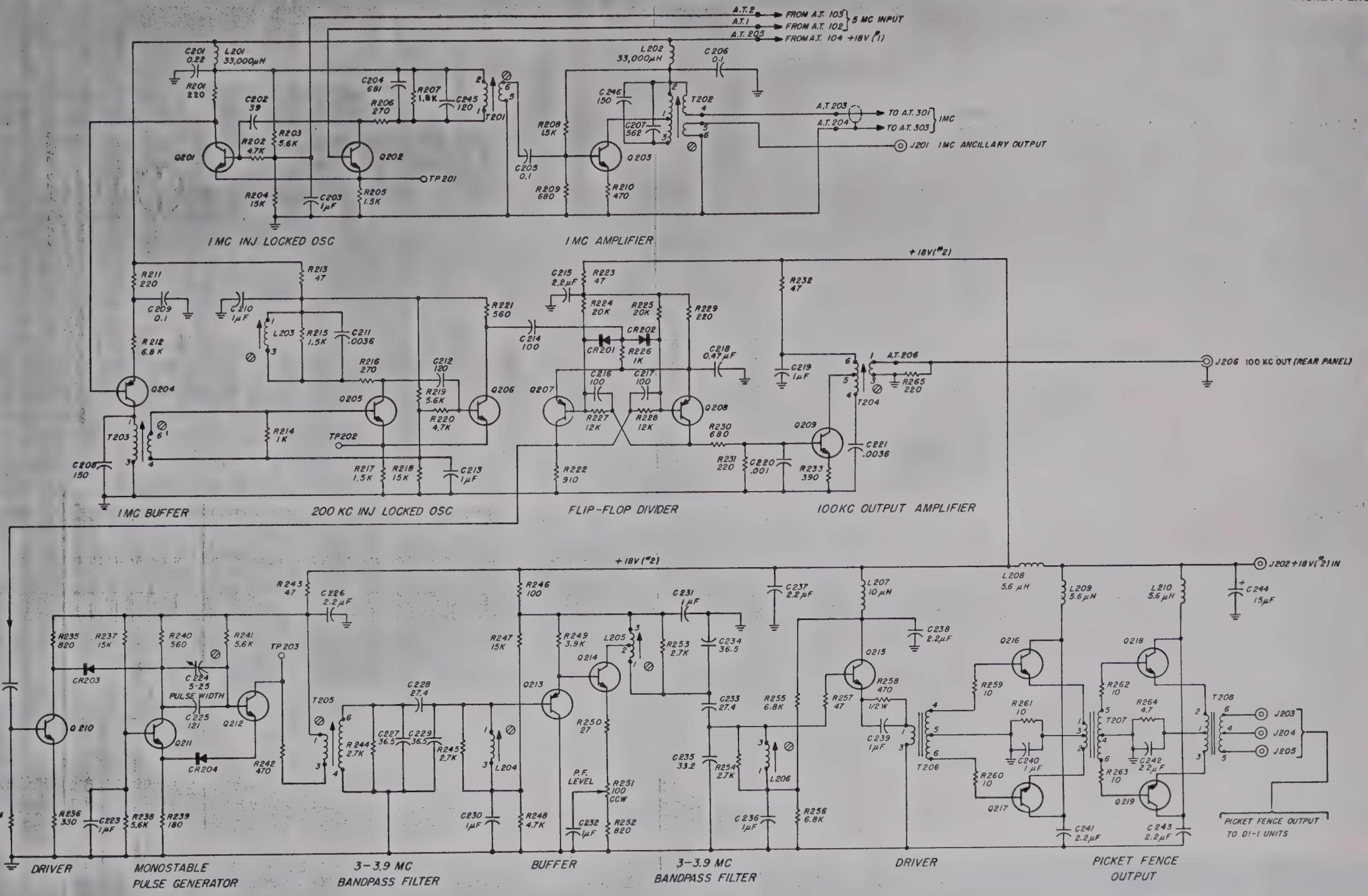
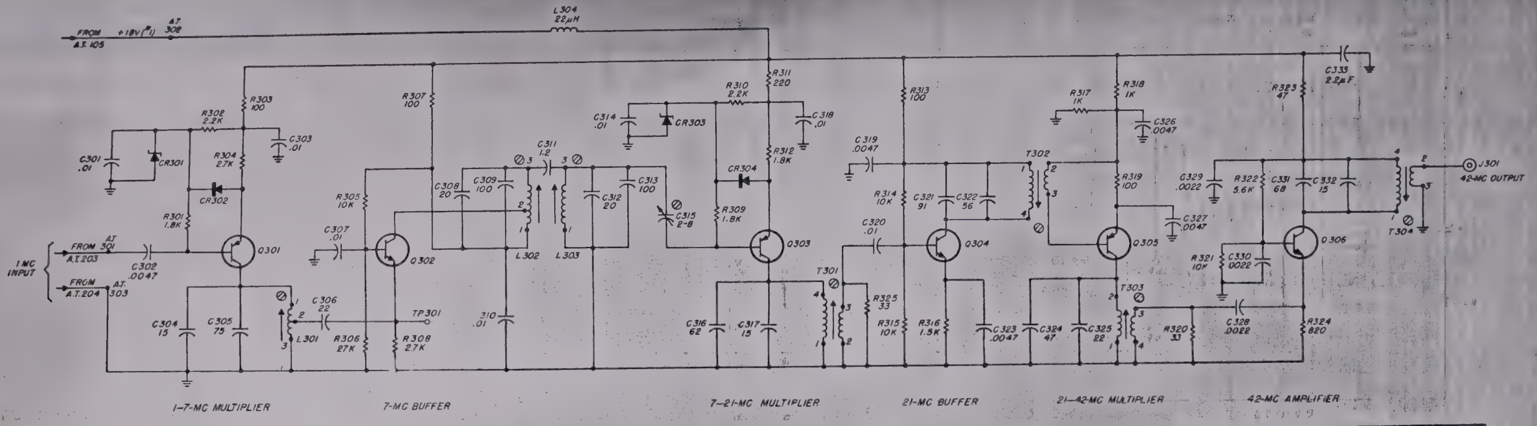
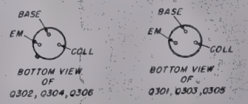

A.T.2
A.T.1
A.T.205
FROM A.T. 103
FROM A.T. 102
5 MC INPUT
FROM A.T. 104 +18V (#1)
A.T.203
A.T.204
TO A.T.301
TO A.T.303
1MC
J201 1MC ANCILLARY OUTPUT
TP201
1MC INJ LOCKED OSC
1MC AMPLIFIER
+18V (#2)
J206 100 KC OUT (REAR PANEL)
A.T.206
TP202
1MC BUFFER
200 KC INJ LOCKED OSC
FLIP-FLOP DIVIDER
100KC OUTPUT AMPLIFIER
J202 +18V (#2) IN
100 KC
TP203
PULSE WIDTH
P.F. LEVEL
CCW
J203
J204
J205
PICKET FENCE OUTPUT TO DI-1 UNITS
DRIVER
MONOSTABLE PULSE GENERATOR
3-3.9 MC BANDPASS FILTER
BUFFER
3-3.9 MC BANDPASS FILTER
DRIVER
PICKET FENCE OUTPUT

Figure CA-11.
Schematic diagram for Picket Fence Section.

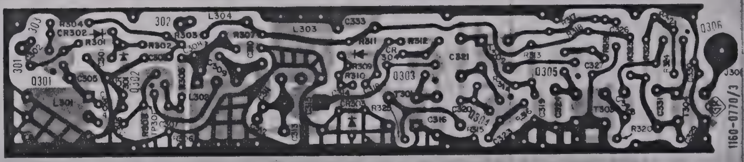

FROM A.T. 105
+18V (*1)
A.T. 302
L304 22µH
R303 100
R302 2.2K
C303 .01
C301 .01
CR301
R304 2.7K
CR302
R301 1.8K
1 MC INPUT
FROM A.T. 203
A.T. 301
C302 .0047
FROM A.T. 204
A.T. 303
Q301
C304 15
C305 75
L301
1
2
3
C306 22
TP301
R306 27K
R308 2.7K
R305 10K
C307 .01
Q302
R307 100
C308 20
C309 100
L302
310 .01
C311 1.2
L303
C312 20
C313 100
C314 .01
CR303
C315 2-8
R310 2.2K
R311 220
C318 .01
R312 1.8K
CR304
R309 1.8K
Q303
C316 62
C317 15
T301
4
1
3
2
R325 33
R313 100
C319 .0047
R314 10K
C320 .01
R315 10K
Q304
C321 91
C322 56
R316 1.5K
C323 .0047
T302
R318 1K
R317 1K
C326 .0047
R319 100
C327 .0047
Q305
T303
C324 47
C325 22
R320 33
C333 2.2µF
R323 47
C329 .0022
R322 5.6K
C331 68
C332 15
R321 10K
C330 .0022
Q306
C328 .0022
R324 820
T304
J301
42-MC OUTPUT
1–7-MC MULTIPLIER
7-MC BUFFER
7–21-MC MULTIPLIER
21-MC BUFFER
21–42-MC MULTIPLIER
42-MC AMPLIFIER


BASE
EM
COLL
BOTTOM VIEW OF Q302, Q304, Q306
BASE
EM
COLL
BOTTOM VIEW OF Q301, Q303, Q305

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

Figure CA-12.
Schematic diagram for 42-Mc Section.


301
302
303
Q301
L301
CR302
R304
R301
R302
R303
R307
L302
L304
L303
C333
R311
R312
R309
R310
Q303
C321
R313
Q305
C327
T303
R320
C316
TP301
1160-0770/3
Q306

42-Mc Circuit etched-board assembly (P/N 1160-2770).

NOTE: The number appearing on the foil side is not the part number.

SERVICE INSTRUCTIONS

section DA

DIGIT-INSERTION UNIT, DI-1

P/N 1160-4000

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rm No. 1160-4000-A ID Number B29 February 1966

GENERAL RADIO COMPANY
West Concord, Massachusetts

SECTION DA-1

INTRODUCTION

DA-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section is prepared from a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis."

Included in the following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension by experienced service personnel of the principles of operation. A trouble-analysis procedure that will aid in isolation of defective circuits completes the section.

To facilitate part identification, reference designators used in the text and appearing on the photographs are the same as those used on the complete schematic diagram and in the parts list.

The service instructions rely on the use of a properly functioning synthesizer as a basic test frame for an individual module. The instrument can be used to support the module, in a convenient bench-service position, and to supply it with power and test signals.

NOTE

First consideration should be given to the use of the widespread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty.

DA-1.2 PURPOSE.

In General Radio synthesizers, output-frequency generation (in accordance with the setting of the front-panel dials) is accomplished by the modules occupying the top of the Main Frame chassis. Of these, the majority are identical and interchangeable and permit selection of crystal-locked frequencies in steps ranging from 0.01 c/s to 100 kc/s, depending on the model and the position of the module. They are called Digit-Insertion unit, type 1 — DI-1 for short.

Solid-state circuitry that performs this operation, with the aid of certain fixed direct derivatives of the master crystal oscillator, is self-contained in the DI-1 package, shown in Figure DA-1. The unit is a convenient plug-in module; all external connections are made automatically as it is installed.

NOTE

Most DI-1 modules in the field bear a front—panel marking "ID-BXX"; some early versions do not. Text in this section covers both, but a separate schematic and parts list, for modules not so marked, appear in Section DA-4.

DA-1.3 DESCRIPTION.

The DI-1 Digit-Insertion unit, with its cover installed, is shown in Figure DA-1. The only external operator control of the unit, the digit-selector switch, is operated by the 1/4-inch shaft and the dial knob visible in front. A small plastic lamp holder, which is part of the DI-1 as supplied, fits in the synthesizer panel behind the DI-1 control knob. This holder permits installation of the dial lamp in the instrument front panel, behind the dial, after the DI-1 has been mounted in the Main Frame (see Figure 5-2 in the systems portion of this manual).

The entire DI-1 assembly is held in the Main Frame by two 4-40 screws that engage the threaded bushings in the top corners of its small front panel and by a hold-down clamp that secures the reinforced bottom of the cover unit at the rear, through a small cutout.

All electrical connections except one are made by banana-type plugs from the Main Frame through the bottom of the cover into the DI-1 assembly. The dial lamp is energized and switched in the Main Frame as explained in Section 4.6 (system portion). It can also be controlled from the DI-1, and this control-signal connection is made by a small pin in the DI-1 front panel to a spring contact on the instrument front panel. This pin is part of a phase-error sensing circuit that extinguishes the lamp if phase lock is broken. All connections are thus established automatically when the unit is installed.

Three 4-40 screws on either side of the unit fasten the cover to the Digit-Insertion unit frame structure. After their removal, the unit can be withdrawn from the cover, if the case is held in one hand and the unit is pulled by its switch shaft with the other.

The circuitry of the DI-1 is contained on four etched-circuit boards. They are the long horizontal top and bottom boards and the smaller vertical front and rear circuit boards. These boards mount all components and furnish most of the electrical connections between them. In the bottom board are 6 banana jacks and 2 special ground contacts, which make the electrical connections to the Main Frame mentioned earlier.

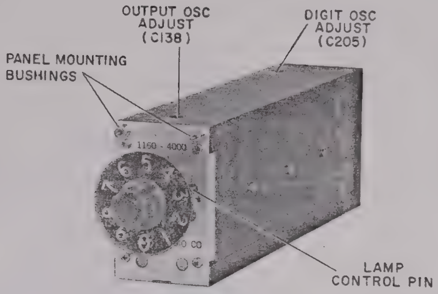


Figure DA-1.
Digit-Insertion Unit, DI-1 (P/N 1160-4000).

Signal flow and circuit layout are so arranged that a minimum of wiring between boards is required and each individual board assembly can be removed from the structure, after connecting-wire leads have been unsoldered and appropriate screws removed. There is, however, enough space in almost all instances to permit removal of components without board removal.

The side rails of the top and bottom boards are equipped with special ground springs to ensure intimate contact with the cover. The 6 threaded inserts, which accept the 4-40 screws that hold the cover, establish fixed contact areas between shield partition and cover. A finger-stock rf seal is used where the cover and front panel join.

SECTION DA-2

PRINCIPLES OF OPERATION

DA-2.1 GENERAL.

The main circuits of the DI-1 are shown in the block diagram, Figure DA-2 (see also the full schematic diagram, Figure DA-9 or -10).

In accordance with the flow in the synthesizer itself, where the signal is fed from DI-1 to DI-1 (from right to left), the main signal flow in the block diagram is from right to left, along the horizontal axis of the figure.

Ancillary signals, which are used in common by all DI's, consist of the 42-Mc signal to the Input Mixer and the Picket-Fence input to the Digit Phase Detector. These signals are supplied by the AFS unit (Section CA), from common busses in the Main Frame chassis (Sections BA, BB).

Operating frequencies, or frequency bands, are indicated inside the blocks of the diagram. Above the blocks, frequencies that would result from an arbitrary input frequency of 5.069 Mc/s and a digit selection of 5 are indicated as an example.

A simple numerical example will serve to explain this operation:

Since (from paragraph 4.4)

$$f_{out} = f_c + \frac{f_{s_{in}}}{10} + 10d \qquad kc/s$$

and if

$$f_{s_{in}} = f_{in} - f_c$$

so that

$$f_{out} = f_c + \frac{f_{in} - f_c}{10} + 10d,$$

with

$$f_{in} = 5069 \qquad kc/s$$

and

$$d = 5 \text{ (digit setting)},$$

then

$$f_c = 5000.0 \qquad kc/s$$

$$\frac{f_{in}-f_c}{10} = 6.9 \qquad kc/s$$

$$10d = 50.0 \qquad kc/s$$

with the result that

$$f_{out} = 5056.9 \qquad kc/s$$

From the comparison of f_{in} and f_{out}, it is obvious that in f_{out} a "5" has been *inserted* between the 0 and 6 of the input frequency.

DA-2.2 SIGNAL FLOW.

The input signal, 5.069 Mc/s in the example, reaches the Input Mixer through a fixed-tuned transformer. The amplified 42-Mc signal from the AFS is added here and the upper sideband is selectively amplified in the following buffer. This signal of 47.069 Mc/s is fed into the Digit Mixer, where a 100-kc multiple between 3.0 and 3.9 Mc/s is added. This "digit" signal comes from the Digit Oscillator, which is phase-locked to a particular component in the Picket Fence, as described below.

The number following the decimal point in the Digit-Oscillator frequency (in Mc/s) is the same as the number to which the digit-selector dial has been set, so that 3.0 Mc/s corresponds to "0", 3.1 Mc/s to "1", and so on. If, as in this example, the dial has been set to digit "5", then 3.5 Mc/s is added to 47.069. The resulting upper sideband of this mix is 50.569. This signal is filtered, amplified, and fed into the Divider Phase Detector.

The remainder of the main signal circuit produces, in effect, a division by 10 and as a result the

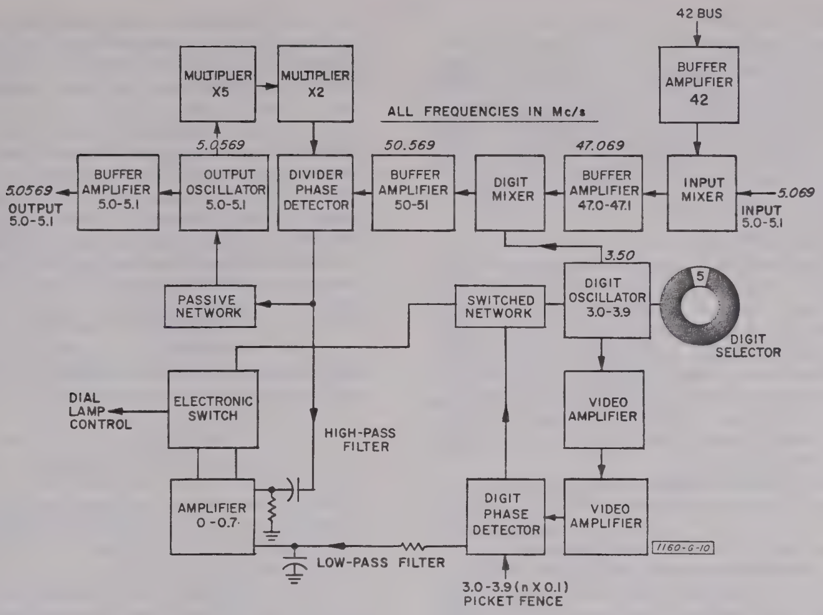

42 BUS
MULTIPLIER X5
MULTIPLIER X2
ALL FREQUENCIES IN Mc/s
BUFFER AMPLIFIER 42
5.0569
50.569
47.069
5.0569
OUTPUT 5.0-5.1
BUFFER AMPLIFIER 5.0-5.1
OUTPUT OSCILLATOR 5.0-5.1
DIVIDER PHASE DETECTOR
BUFFER AMPLIFIER 50-51
DIGIT MIXER
BUFFER AMPLIFIER 47.0-47.1
INPUT MIXER
5.069
INPUT 5.0-5.1
3.50
PASSIVE NETWORK
SWITCHED NETWORK
DIGIT OSCILLATOR 3.0-3.9
5
DIGIT SELECTOR
DIAL LAMP CONTROL
ELECTRONIC SWITCH
HIGH-PASS FILTER
VIDEO AMPLIFIER
AMPLIFIER 0-0.7
DIGIT PHASE DETECTOR
VIDEO AMPLIFIER
1160-G-10
LOW-PASS FILTER
3.0-3.9 (n X 0.1) PICKET FENCE

Figure DA-2. Simplified block diagram for Digit-Insertion Unit.

Output Oscillator is now set to 5.0569. This frequency is amplified and appears at the output terminal of the DI-1. If we compare the input and output frequencies, we note that the "69" digits in the input have been shifted to the right by one position and that a 5 has been inserted in front of them. This is the general process, which is implemented as shown by the other blocks in the diagram.

On the top right-hand side of the diagram, there is a tuned 42-Mc amplifier that takes a signal from a 42-Mc bus (generated by the AFS), amplifies it, and injects it into the balanced mixer. The main purpose of this amplifier is to provide isolation between the 42-Mc bus in the Main Frame and the Input Mixer. The 47+ signal without such isolation could enter other DI units and create spurious products.

The Digit Mixer 3.0 – 3.9-Mc input signal comes from the step-tuned Digit Oscillator, which, through amplifiers, feeds one input of the Digit Phase Detector. The reference input to this Phase Detector is the Picket Fence, consisting of a group of 100-kc standard-frequency multiples lying between 3.0 and 3.9 Mc/s. This group of signal frequencies of equalized amplitude is also supplied by the AFS.

The Phase-Detector output controls the oscillator frequency by means of varactor diodes. This phase-lock loop locks the Digit Oscillator to a frequency controlled by the primary crystal oscillator in the AFS. The Digit Oscillator is tuned approximately to one of the ten frequencies by a switch controlled by the panel digit-selector knob. For the ten frequencies, the Digit Oscillator employs a tracking scheme that minimizes the number of capacitive trimmers and adjustments required. To the tuned-element sets used for the five higher frequencies, two padders are added so that the lower five frequencies fall into place with only one adjustment. Mistracking, when equalized, is 2 kc/s maximum.

Division by 10, from 50+ Mc/s to 5+ Mc/s, is achieved with phase lock in subsequent stages. The Output Oscillator signal is multiplied by 5, then by 2, and fed into a phase detector, the other side of which is fed by the filtered Digit-Mixer output frequency (in the example, 50.569 Mc/s). The Output-Oscillator frequency is varactor-controlled by the Divider-Phase-Detector output and, therefore, the frequency of the oscillator in the locked condition is one-tenth the reference frequency from the Digit Mixer.

From Figure DA-2 it can be seen that the two phase detectors have output connections to a 0 – 0.7-Mc amplifier, through high- and low-pass filters. The amplifier feeds an electronic switch. As long as ac signals in the passband of the filters are present, the switch is open and the bandwidth of the switched network is wide. This is the condition prior to capture; after capture, the ac components disappear, the switch closes, and the bandwidth is narrowed. Reduction of bandwidth is necessary in the digit phase lock, where all pickets are present simultaneously to minimize 100-kc spurious sidebands. "Capture" is indicated by the dial light, which is extinguished if either oscillator fails to lock.

DA-2.3 CIRCUIT DETAILS.

DA-2.3.1 GENERAL.

Circuits and the location of prominent components will be discussed in the sequence in which the signal passes through a Digit-Insertion unit. Reference will be made to the block diagram Figure DA-2, as well as the over-all schematic diagram, Figure DA-9. Figure DA-3 will be a useful reference for physical identification of the circuits discussed.

DA-2.3.2 INPUT SECTION.

The input section consists of an Input Mixer preceded by a 42-Mc Buffer and followed by a 47 – 47.1-Mc Buffer. The 42-Mc Buffer is a common-emitter stage, Q306, with a tuned output coil, L303, that serves as isolator, amplifier, and impedance transformer for the 42-Mc signal from the AFS. This signal is taken from the 42-Mc bus, through J306, and processed for injection at the Input Mixer. The input network of the buffer is of moderately high impedance and is broadly tuned.

The Input Mixer combines the incoming 5.0 – 5.1-Mc signal from J305 and the 42-Mc signal from the buffer. The 5.0 – 5.1-Mc input, of approximately 0.30 V, is stepped up in T302 and applied to Q303 and Q304. The connection between L303 and T302 feeds the 42-Mc signal to the transistors in-phase and also completes the bias circuit. The balanced configuration, together with the circuit (T303, C314, C315) tuned to the upper sideband (47 – 47.1 Mc/s), effectively eliminates the 42-Mc component in the output and provides substantial rejection for the ninth-harmonic component of the 5 to 5.1-Mc input signal.

Q305 is a transformer-coupled buffer-amplifier which amplifies the 47 – 47.1-Mc signal for application to the Digit Mixer. Tuned output coil L306 further contributes to the selectivity provided for the suppression of unwanted mixer-output components.

The input circuits described above occupy the front right-hand side of the bottom circuit board (see Figure DA-3).

DA-2.3.3 DIGIT MIXER AND 50 – 51-Mc BUFFER.

Wire links, joined through the central shield partition by AT502, bring the 47 – 47.1-Mc signal from the Q305 buffer stage to C103 and C104 (at the rear of the top board), which form the input to the Digit Mixer. The second signal into this mixer is the Digit-Oscillator output of 3.0 – 3.9 Mc/s, in 100-kc steps. The resultant output of 50 – 51 Mc/s (47 + 3.0 to 47.1 + 3.9 Mc/s) is filtered in the tuned circuit T101/C105 and applied to the following buffer, Q103. To obtain an equalized output over the 1-Mc bandwidth, a double-tuned filter (compensating the response of the preceding single-tuned circuit) couples the signal into the Divider Phase Detector.

The Digit Mixer and Buffer circuits are located on the top board at the back end (see Figure DA-3).

DA-2.3.4 OUTPUT OSCILLATOR/MULTIPLIER.

The output signal of 5.0-5.1 Mc/s is generated in a Colpitts oscillator (Q104). The tuned circuit includes the varactor diode, CR103, which makes the oscillator voltage-tunable.

Transistors Q106 and Q107 perform the multiplication of the oscillator frequency by ten. Both are class-C multipliers that are tuned to the desired harmonic of the input frequency in the respective collector circuits. L107/L108 are resonated at approximately 25.25 Mc/s and T104/T102 are tuned to about 50.5 Mc/s.

The above circuits, from the oscillator through the multipliers into the Divider Phase Detector (a conventional half-bridge circuit), and from its output through filter circuits back to varactor-diode CR103, form a phase-lock circuit. Once captured, the oscillator frequency is kept at exactly 1/10th the reference frequency (50-51 Mc/s) by a dc voltage applied to the varactor diode. This voltage is developed in the phase detector.

If a different dc voltage is required on the varactor diode, to compensate for circuit drifts in the oscillator for instance, only the relative phases of the two inputs to the phase detector change. Potentiometer R109 sets the initial back-bias for the varactor diode and, therefore, affects the free-running oscillator frequency.

During the process of capture (the synchronization of the oscillator frequency with the reference frequency), the oscillator is frequency-modulated initially with the frequency difference between the

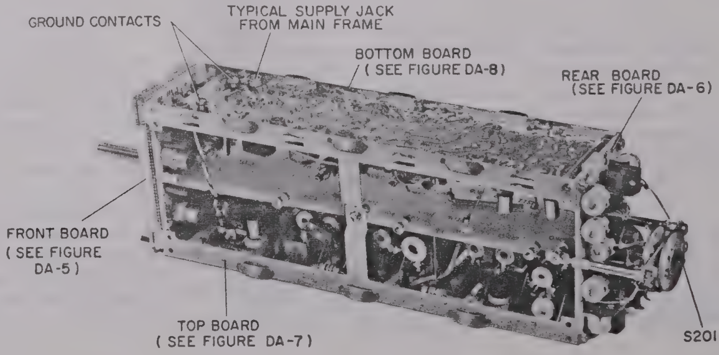

GROUND CONTACTS
TYPICAL SUPPLY JACK FROM MAIN FRAME
BOTTOM BOARD (SEE FIGURE DA-8)
REAR BOARD (SEE FIGURE DA-6)
FRONT BOARD (SEE FIGURE DA-5)
TOP BOARD (SEE FIGURE DA-7)
S201

Figure DA-3. DI-1 module with cover off (inverted). Referenced figures give circuit-layout details.

reference and its own frequency multiplied by ten. Sidebands of this modulation have to be passed by the multiplier circuits and they are therefore considerably wider in bandwidth than the 5-5.1 or 50-51 Mc/s would suggest.

The Output Buffer, Q105, is a broadly tuned, common-emitter stage following the oscillator. The output voltage of approximately 0.30 V, rms, is fed to J304. Note that the contact associated with J304, as well as the contact near the input (J305), is not internally grounded. Ground springs on the Main Frame connect both the output and input ground contacts of adjacent DI-1 units. The fact that the springs are connected to the chassis in only one place increases the isolation of the input and output circuits, since the chassis has to carry no current.

The Output Oscillator, Output Buffer, and multipliers are located in the front half of the top circuit board (Figure DA-3).

DA-2.3.5 DIGIT-OSCILLATOR PHASE LOCK.

The Digit Oscillator provides injection frequencies to the Digit Mixer, which are the crystal-locked 100-kc steps between 3.0 and 3.9 Mc/s. While all of these frequencies are present simultaneously in the Picket Fence (generated in the AFS), only one specific frequency is required for each setting of the digit-selector dial (S201). All others must be kept out ot the Digit Mixer, in order to avoid spurious outputs. The selection and filtering of the proper Picket-Fence frequency is achieved by a step-tuned oscillator and a phase-lock loop.

Colpitts-oscillator Q201 is tuned to each of the ten frequencies by switch-selected trimmer capacitors, C201 through C205. C205 is always connected and is used alone to adjust the 3.9-Mc top frequency initially (digit-selector setting 9). Digits 8, 7, 6, and 5 are set by C204, C203, C202, and C201, in that order. At this midband point, a pair of padder capacitors (C211 and C212) is added as shown to select digit 4 and the lower digits. After adjustment of the 3.4-Mc frequency with C211, the lower frequencies are obtained automatically with the same trimmer-capacitor settings used for the corresponding higher frequencies. The circuit inductance, T201, is preadjusted to the proper value so that tracking errors are kept below ±2 kc/s. As in the Output Oscillator, part of the C in the tuned circuit is represented by voltage-variable capacitance (CR201 and CR202), to obtain phase-lock capability.

Two video-amplifier stages, Q301/Q302, amplify the oscillator signal for injection into the Digit Phase Detector. The reference side of the phase detector is transformer-connected (T301) to the balanced Picket-Fence bus in the Main Frame. The phase-detector control-signal output is filtered and applied to the varactor diodes, CR201 and CR202. If the Digit-Oscillator free-running frequency deviates from the chosen crystal-derived Picket-Fence frequency, the phase of this oscillator signal shifts, until the phase detector produces enough dc output to correct the oscillator frequency by means of the varactor diodes.

Picket frequencies to which the oscillator is not locked produce 100-kc, 200-kc, etc, outputs from the phase detector that would frequency modulate the oscillator, if not suppressed. Consequently, sufficient attenuation of these signals and retention of adequate capture range are conflicting requirements. The filter, in the "Control" line between the phase-detector output and the oscillator varactor diodes, therefore, operates in two modes, as selected by the filter-switching circuit (Q403-Q405). The filter passband is wide for the capture process and narrow for normal operation, after capture has been attained. The normal back-bias for the varactor diodes is established by potentiometer R311.

The DI-1 output frequency changes 10 kc/s for every 100-kc step of the Digit Oscillator or 90 kc/s for the total Digit-Oscillator range of 900 kc/s, because of the division-by-ten following the Digit Mixer. The 100-kc range, from 5.0-5.1 Mc/s in the input frequency, is reduced to 10 kc/s in the output for the same reason. This means that 90% of the signal supplied as reference to the Divider Phase Detector comes from the Digit Oscillator and only up to 10% from the input signal.

Thus, the Digit Oscillator setting can be used to preset output-oscillator tuning in the correct general region for easy capture. The feedthrough (via AT504) from the Digit Oscillator through R206 and R127, to the arm of R109, shifts the free-running frequency of the Output Oscillator. By variation of the dc bias on the varactors, it is shifted from approximately 5.025 Mc/s (for digits 0 through 4) to approximately 5.075 Mc/s for digits 5 – 9.

NOTE

> This shift connection is used in DI-1 units with the ID-BXX markings on the front panel. Refer to Section DA-4 for details on early models.

The Digit Oscillator is located on the rear board, while the two video stages and the Digit Phase Detector occupy the rear half of the bottom board (see Figure DA-3).

DA-2.3.6 LOCK SENSING AND FILTER SWITCHING.

Capture of the two phase-lock loops, the divider main loop and the digit-oscillator loop, is monitored by the lock-sensing and filter-switching circuit. The input amplifiers, Q401 and Q402, are connected to the phase detectors to amplify ac output signals present. Any two signals that enter the phase detectors without achievement of lock will produce an ac output that corresponds to their frequency difference. This output is applied to the voltage-doubler-rectifier, CR401/CR402, and is used to cut off transistors Q403 through Q405. This will (in turn through the lamp-control pin) extinguish the dial lamp on the front panel, to give warning of malfunction.

In the normal condition of this switch, stages Q403 through Q405 are turned on, effectively shorting

C306 in the filter network that follows the Digit Phase Detector. This effect introduces a low-frequency cutoff network (R315, C306) and lowers the loop gain by the loading of the phase-detector output with R314.

If the Digit Oscillator is now switched to a new frequency (which might be slightly off from the crystal-derived Picket Fence) the beat note, through R306-R401, will be applied to the amplifiers and open the switch. This will unground C306 and thereby shunt R315 with R314. The bandwidth is widened, the load is removed from the phase detector, and capture can now be attained. As the beat note disappears from the phase-detector output after capture, the switch will return to the normal, closed position.

R306/C301 and R401/C402 form a low-pass filter to prevent the 100-kc beat note, which is always present in the Digit Phase Detector due to adjacent pickets, from opening the switch.

SECTION DA-3

SERVICE AND MAINTENANCE

DA-3.1 INTRODUCTION.

If the system self-check procedures of Section 5 (front part of the manual) indicate that service is required for a DI-1 unit, remove the unit from the chassis (paragraph 5.4.2) and replace it with a bridging unit (paragraph 5.5.1).

It is recommended that the DI unit be returned for service to the General Radio Company (particularly within warranty). Where this is not possible, certain tests can be made in the field, but a thorough understanding of the principles of operation is essential (refer to Section DA-2 above).

The procedures that follow will permit isolation of the fault, so that corrective measures can be taken. Since the synthesizer Main Frame can be used as a test fixture, refer to the appropriate Main Frame chassis schematic (Section BA or BB), as well as to the over-all schematic for the DI-1 unit, Figure DA-9.

NOTE

Reference is made to banana plugs and other test points on the Main Frame by the designations used in Chassis 1160-4060.

DA-3.2 TEST EQUIPMENT REQUIRED.

Table DA-1 lists recommended test equipment required to test the DI-1 module. Equivalent equipments may be substituted.

DA-3.3 TROUBLE ANALYSIS.

DA-3.3.1 GENERAL.

CAUTION

Turn power off during set-up changes to avoid accidental short circuits, which can blow F503 in the Power Supply module (PS-1).

Remove the malfunctioning DI-1 unit from the Main Frame and withdraw the unit from its cover, after removal of the three 4-40 screws on each side. Reinstall the open unit (complete with dial lamp) carefully in station VII, next to the CAD unit. Remove the CAD unit, as in paragraph 5.4.3 (front part), as well as the DI unit in station VI. Do not install a bridging unit in this space. The Calibrating Mixer module does not have to be removed.

Use Figure DA-4 to locate interior test points, which for the most part are simple wire loops in the top circuit board of the unit.

DA-3.3.2 POWER INPUT.

With the VTVM look for +18 ±0.2 Vdc at AT205 on the rear circuit board. If the indication is abnormal, check the distribution of this supply voltage in the Main Frame chassis and this output of the Power

TABLE DA-1

TEST EQUIPMENT REQUIRED

Function	*Type Recommended*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806-A (with 1806-P1 probe)	BW 1-55 Mc/s; sensitivity 0.2 V; probe capacity 2.0 pF maximum
Digital Frequency Meter	GR 1143-A or 1144-A	Dc to 50 Mc/s; resolution 100 c/s; sensitivity 0.1 V; input impedance >500 ohms
Oscilloscope	Tektronix 543 (with C/A plug-in and P6006 10× probe)	20 Mc/s, 0.5 V/cm, 8 pF (or less) probe.

Supply module. If the indication is normal, continue with the procedures below.

DA-3.3.3 OUTPUT OSCILLATOR/OUTPUT BUFFER.

Connect the oscilloscope or the VTVM between PL212-6 and the ground spring on the top deck of the Main Frame, to the left of the DI-1 under test. Depress the CAD OFF button and turn the POWER switch on. An rf voltage of 0.2 to 0.4 V, rms, should be present. If no indication is obtained, or if inadequate voltage is observed, the Output-Oscillator (Q104) or the Output-Buffer (Q105) circuit is probably faulty.

DA-3.3.4 PHASE-LOCK LOOP TESTS.

If the proper output voltage was present in the preceding test, confirm that an input signal to the DI-1 under test is present at PL213 on the Main Frame top deck. This should be about 0.3 V, rms, at 5.0 Mc/s.

Then, connect the digital frequency meter to PL212-6 (connects with J305 on DI-1) and observe the output frequency corresponding to various dial positions of the DI unit. A properly functioning unit would indicate 5.0100 Mc/s for digit 1, 5.0200 Mc/s for digit 2, and so on. If steps of nearly (but not exactly) 10 kc/s are obtained, the main loop is functioning properly, but the digit-oscillator loop is not locked.

If, however, the frequency does not move in steps of exactly 10 kc/s in accordance with the dial, or if only certain of the frequencies (like 5.0500 Mc/s for digit 5) are obtained exactly and others are off, the main loop is out of order. (Operation of the digit phase-lock loop cannot be tested at the output of the DI unit, where the counter is connected, as long as the main phase-lock loop is out of order).

Indications of the dial lamp will permit further conclusions about the two phase locks. If the dial lamp is extinguished while an improper frequency is shown, both signals into the Divider Phase Detector are present but they are not locked. This may be due to low signal level or to improper free-running oscillator frequency. If the lamp remains turned on, however, lock failure is probably due to lack of at least one of the input signals to the phase detectors. The dial-lamp sensing circuits monitor both the divider phase lock and the digit phase lock.

Depending upon which of the two phase-lock loops is suspected of malfunction, select the appropriate procedure among the two that follow.

Output-Oscillator (C138) trimmer, and Digit-Oscillator (C205) trimmers, are accessible through the DI-1 cover. It is sometimes possible to correct oscillator frequencies (as a temporary measure) by tuning the proper capacitor until lock is achieved (dial lamp will relight). Verify operation with the counter and set the trimmer to the mechanical midpoint of the capture range. Determine capture range by turning the unit on and off with the power switch, while altering the trimmer position in small steps until lock (proper frequency and lamp "on") can no longer be attained.

DA-3.3.5 MAIN-LOOP TESTS.

The main loop is comprised of the majority of the circuits in the DI-1 and includes: the Input Mixer, the 42-Mc Buffer, the 47/47.1-Mc Buffer, the Digit Mixer, the Digit Oscillator (without its phase lock), the 50/51-Mc Buffer, the Divider Phase Detector, the Ouput Oscillator and Buffer, and the X5 and X2 Multipliers.

Output-Oscillator Free-Running Frequency

Depress the button under the CAD unit. Connect TP104 to TP105 with a 10-ohm resistor (use Alligator clips), to disable the phase detector. Turn the power on and observe the output-oscillator free-running frequency with the digital frequency meter connected to PL212-6, as before. The indication should be 5080 ±3 kc/s for digit settings 9 through 5, and 5030 ±3 kc/s for digit settings 4 through 0. Reset the frequency with C138, if necessary.

NOTE

For units without the ID-BXX marking, the indication should be 5060 for all digit settings.

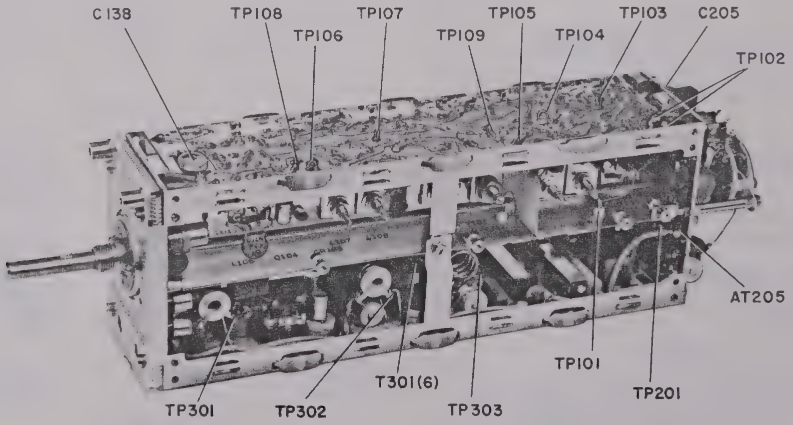


Figure DA-4. DI-1 interior test points and adjustments. Top right oblique view.

This test can also be performed without a digital frequency meter, if a working CAD unit and the Calibrating Mixer are used instead as a frequency meter. To do this, install the CAD unit in the chassis in the usual manner. Connect TP103 in the DI-1 to case ground, with a short clip lead to prevent signal leakage, and use the 10-ohm resistor between TP104 and TP105, as described above.

To compare frequencies, set the front-panel MONITOR switch to CAD CAL, push the CAD substitution button under the DI-1 to be examined, and tune the CAD for a null indication (or a slow beat) on the meter. With the CAD in the INTERNAL LOCK mode, the significant last two digits can be read directly on the CAD dial; 5030 kc/s will read as 30 on the CAD dial, etc. Remove the CAD after this test; the Calibrating Mixer can remain. Also remove the 10-ohm resistor and the ground lead at TP103.

Divider-Phase-Detector Input (Oscillator Side)

If the Output Oscillator is operative, the next step is to check the Divider-Phase-Detector input, and then work back from there.

To do this, first depress the button under the CAD unit. Since the CAD is not installed in the Main Frame, there will be no input to the DI-1 under test (in Station VII) and, therefore, there should be no signal at TP104. Connect the VTVM (15-V scale) between case ground and TP109; a 50-Mc voltage of 3 to 4 V should be present.

NOTE

Units not marked ID-BXX on front panel should read 5.0 to 6.5 V.

If not, measure the voltage at TP107, which should be approximately 1.6 to 2.2 V at 25 Mc/s. The output oscillator amplitude measured at TP106 should be 2.5 to 2.9 V at 5 Mc/s.

Divider-Phase-Detector Input (Reference Side)

Retain the test conditions of the previous paragraph to measure the input to the Divider Phase Detector. Ground TP108 to disable the Output Oscillator. Depress the CAD OFF button, thus restoring an input signal at 5 Mc/s to the DI-1, and measure the voltage from TP104 to ground. A signal of 2.5 to 3.5 V at 50 Mc/s should be obtained, which peaks for the middle digits and drops about equally for digits 0 and 9, when the digit-selector dial is operated.

NOTE

Units without the ID-BXX marking will read 5 to 7 V.

Voltages obtained at TP103 should be 0.5 to 0.8 V, with a peak at digit 5. Connect the digital frequency meter to TP103 to measure frequency. Care should be taken not to measure the image frequency of the Digit Mixer (43.5 Mc/s instead of 50.5 Mc/s for digit 5).

The Digit-Oscillator output-signal amplitude measured at TP201 is 2.5 to 2.9 V, depending on digit setting, or approximately 1 V at TP102 (both meter leads). The second injection into the Digit Mixer is the 47+ Mc signal, 1.6 to 2.5 V, at TP101.

At TP302, 0.8 to 1.3 V of 47+ Mc/s is normally obtained; at TP301, 0.5 to 0.7 V of 42 Mc/s is present.

DA-3.3.6 DIGIT-OSCILLATOR LOOP TESTS.

The Digit-Oscillator loop includes the Digit Oscillator, the two video buffers (Q301/Q302), the Digit Phase Detector, and Picket-Fence input transformer (T301).

Digit-Oscillator Frequency (Free-Running)

To measure the Digit-Oscillator free-running frequency, the Picket-Fence generator in the AFS has to be disabled by removal of the link between terminals 5 and 6 of L501 in the Power Supply module (component side of the etched-circuit board on top of the coil; refer to Section GA). With a properly functioning main loop, the output frequency obtained at PL212-6 for a setting of 9 is 5.0900 Mc/s (CAD OFF button depressed). Reset the DI-1 to this frequency with C205, if necessary.

Digit-Phase-Detector Injection (Oscillator Side)

With the Picket Fence disabled as above, measure the amplified oscillator voltage at L301 via TP303; it should be 6 to 8 V.

Digit-Phase-Detector Injection (Reference Side)

Reconnect the link on the power-supply +18 V bus (L501, 5-6) to the Picket Fence circuitry to measure the input signal at T301. Short TP201 to ground,

TABLE DA-2

TYPICAL DC VOLTAGES
FOR DI-1 UNITS MARKED ID-B29

Transistor	*Emitter*	*Base*	*Collector*
Q101	1.1	0	17.8
Q102	1.1	0	17.8
Q103	1.25	1.4	17.7
Q104	16.0	15.5	0
Q105	17.8	17.5	0
Q106	3.0	0	17.7
Q107	1.75	0	17.2
Q201	16.2	15.7	0
Q301	11.5	11.2	5.1
Q302	15.0	14.5	0
Q303	17.6	17.8	0
Q304	17.6	17.8	0
Q305	0.5	0.95	17.5
Q306	0.7	1.30	17.7
Q401	4.0	4.7	11.3
Q402	11.5	11.2	8.5
Q403	1.1	0.90	0.73
Q404	1.25	1.05	1.1
Q405	1.3	1.10	1.25

NOTES:

Unit operating with all inputs installed in chassis, no cover.
Voltages measured with Type 1806-A direct.
These are typical readings and they are somewhat dependent. on rf signal levels.
Variations of ±15% are to be expected.

to disable the Digit Oscillator. A peak-reading VTVM will indicate 20 — 30 V at terminals 1 or 6 of T301.

DA-3.4 DC VOLTAGE CHECKS.

The procedures of preceding paragraphs should narrow the search for circuit defects to a circuit function consisting of one or, at most, a few stages. As a further aid to pinpoint the defective part, the information on dc voltage readings is presented in Table DA-2.

DA-3.5 REPAIR AND REPLACEMENT.

Replace defective detail parts (with frequency-insensitive functions) to correct deficiencies indicated by the trouble-analysis procedures.

CAUTION

Replacement of frequency-determining parts will require realignment which cannot be accomplished without special test fixtures.

Figures DA-5 through DA-8 show the physical layout of parts on the various etched-circuit boards of the DI-1 units, to speed positive identification. The reference designators for the parts shown on the boards are the same as those used in the over-all schematic diagram, Figure DA-9, and in the parts list at the end of this section.

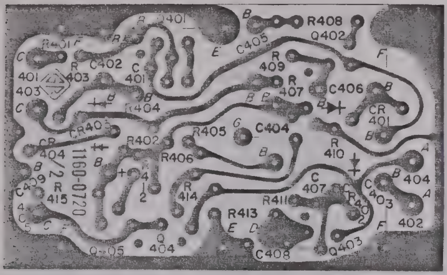

Q401
R408
Q402
R401
C402
R403
C401
401
403
C405
R409
R407
C406
R404
CR405
CR401
R405
C404
R402
R406
R410
C409
R415
1160-0720/2
R414
R413
R411
C407
C403
404
402
Q405
Q404
C408
Q403

Figure DA-5. Front etched-circuit board composite view (P/N 1160-2720).

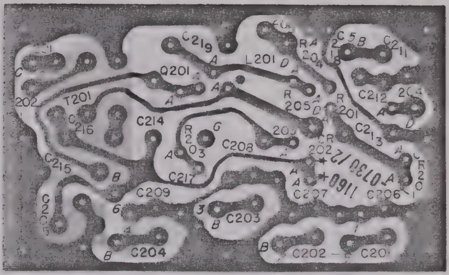

C219
L201
R204
C205
C211
Q201
202
T201
R205
R201
C212
C216
C214
R203
C208
CR202
C213
C215
C217
1160-0730/2
C207
C206
C209
C203
C204
C202
C201

Figure DA-6. Rear etched-circuit board composite view (P/N 1160-2731).

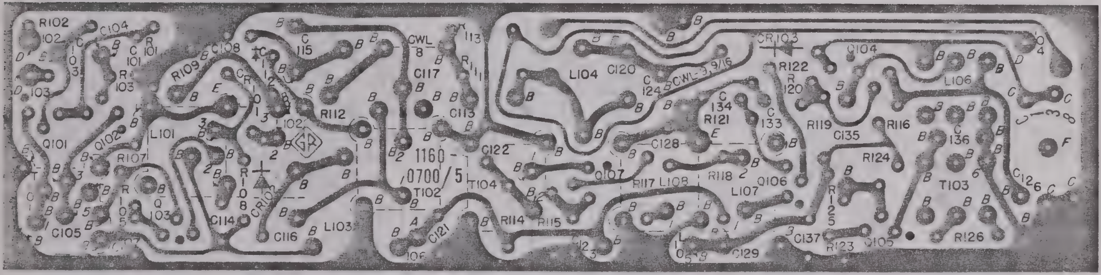

R102
C102
C104
R101
C101
R109
C108
C115
CWL-8
R113
CR103
R122
Q104
L104
C120
C124
CWL-3.9/16
R120
L106
Q103
R103
C117
C113
R112
C134
R121
C133
R119
C135
R116
C136
Q101
Q102
L101
R107
1160-0700/5
C122
C128
R124
CR102
T102
T104
Q107
R117
L108
R118
Q106
L107
R125
T103
C126
Q103
C105
C114
C116
L103
C121
R114
R115
C137
R123
Q105
R126
C129

Figure DA-7. Top etched-circuit board composite view (P/N 1160-2702).

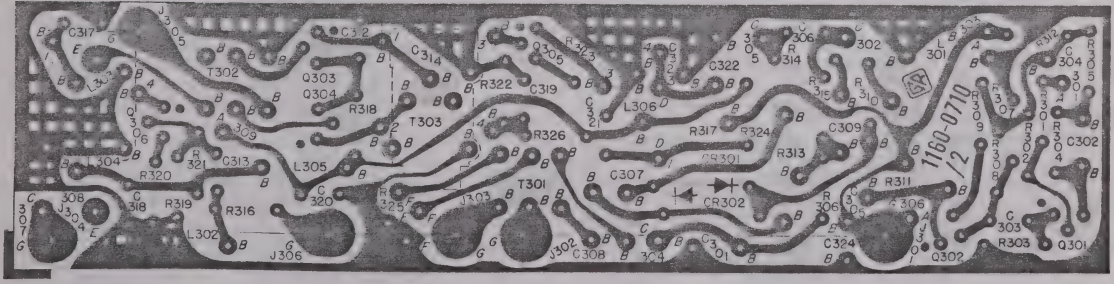

J305
C317
C312
C314
Q305
R323
C306
C302
L301
R312
T302
Q303
Q304
R322
C319
C322
R314
R315
R310
C304
R305
L303
R318
T303
L306
C321
R307
R309
R301
Q306
C309
C309
R326
R317
R324
1160-0710/2
C302
R302
R308
R304
L304
R321
C313
CR301
R313
R320
L305
T301
C307
CR302
R311
C308
J304
C318
R319
R316
C320
R325
J303
R306
C305
C306
C303
L302
J306
J302
C308
C304
C301
C324
J301
Q302
R303
Q301

Figure DA-8, Bottom etched-circuit board composite view (P/N 1160-2712).

NOTE: The number on the foil side is not the part number for the complete assembly.

PARTS LIST

(FOR DI-UNIT WITH ID-BXX MARKING)

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C101	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C102	Ceramic, 0.001 µF +80-20% 500V	4404-2109
C103	Mica, 22 pF ±10% 500 V	4620-0151
C104	Mica, 22 pF ±10% 500 V	4620-0151
C105	Trimmer, 7 to 25 pF 350 V	4910-2032
C106	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C107	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C108	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C109	Mica, 33 pF ±5% 500 V	4700-0301
C110	Ceramic, 1 pF ±10% 500 V	4400-0100
C111	Mica, 33 pF ±5% 500 V	4700-0301
C112	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C113	Mica, 33 pF ±5% 500 V	4700-0301
C114	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C115	Mica, 10 pF ±10% 500 V	4700-0204
C116	Mica, 10 pF ±10% 500 V	4700-0204
C117	Trimmer, 7 to 25 pF 350 V	4910-2032
C118	not used	
C119	Mica, 33 pF ±5% 500 V	4700-0301
C120	Mica, 47 pF ±5% 500 V	4700-0247
C121	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C122	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C123	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C124	Mica, 220 pF ±5% 500 V	4700-0519
C125	Mica, 27 pF ±5% 500 V	4700-0235
C126	Mica, 0.001 µF ±5% 300 V	4700-1190
C127	Ceramic, 43 pF ±5% 500 V (N750)	4417-0435
C128	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C129	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C130	Mica, 200 pF ±5% 500 V	4640-0650
C131	Mica, 12 pF ±10% 500 V	4620-0120
C132	Mica, 120 pF ±5% 500 V	4640-0520
C133	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C134	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C135	Ceramic, 8.2 pF ±5% 500 V	4400-0950
C136	Ceramic, 232 pF ±1% 500 V (N220)	4414-2321
C137	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C138	Trimmer, 2 to 8 pF 350 V	4910-2042
C201	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C202	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C203	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C204	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C205	Trimmer, 7 to 25 pF 350 V	4910-2032
C206	Mica, 91 pF ±5% 500 V	4640-0469
C207	Mica, 56 pF ±5% 500 V	4640-0321
C208	Mica, 33 pF ±10% 500 V	4620-0653
C209	Mica, 10 pF ±10% 500 V	4620-0100
C210	not used	
C211	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C212	Mica, 10 pF ±10% 500 V	4620-0100
C213	Mica, 0.001 µF ±5% 300 V	4700-1190
C214	Ceramic, 150 pF ±5% 500 V (N750)	4417-1155
C215	Mica, 0.0033 µF ±5% 300 V	4580-3300
C216	Mica, 0.00147 µF ±2% 100 V	4700-0687
C217	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C218	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C219	Ceramic, 0.02 µF +80-20% 50 V	4402-3200
C301	Mica, 0.001 µF ±10% 300 V	4700-0200
C302	Mica, 150 pF ±10% 500 V	4700-0440
C303	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C304	Ceramic, 1 µF ±20% 25 V	4400-2070
C305	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C306	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C307	Mica, 100 pF ±10% 500 V	4700-0400
C308	Mica, 100 pF ±10% 500 V	4700-0400
C309	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C310	Mica, 590 pF ±2% 300 V	4700-0730
C311	Mica, 590 pF ±2% 300 V	4700-0730
C312	Ceramic, 470 pF ±10% 500 V	4404-1478
C313	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C314	Trimmer, 7 to 25 pF 350 V	4910-2032
C315	Mica, 110 pF ±5% 500 V	4640-0510
C316	Mica, 100 pF ±2% 500 V	4650-0201
C317	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C318	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C319	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C320	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C321	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C322	Mica, 68 pF ±5% 500 V	4700-0371
C323	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C324	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C401	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C402	Mica, 0.0015 µF ±10% 100 V	4700-0691
C403	Mica, 100 pF ±10% 500 V	4700-0400
C404	Ceramic, 1 µF ±20% 25 V	4400-2070
C405	Ceramic, 1 µF ±20% 25 V	4400-2070
C406	Ceramic, 1 µF ±20% 25 V	4400-2070
C407	Electrolytic, 6.8 µF ±20% 6 V	4450-4800
C408	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C409	Electrolytic, 4.7 µF ±20% 10 V	4450-4700
	DIODES	
CR101	Type 1N995	6082-1002
CR102	Type 1N995	6082-1002
CR103	Type 1N953	6084-1006
CR201	Type 1N953	6084-1006
CR202	Type 1N953	6084-1006
CR301	Type 1N34A (S)	6082-1003
CR302	Type 1N34A (S)	6082-1003
CR401	Type 1N191	6082-1008
CR402	Type 1N191	6082-1008
CR403	Type 1N645	6082-1016
CR404	Type 1N645	6082-1016
	INDUCTORS	
L101	Ferrite cup, adjustable	1160-2270
L102	Ferrite cup, adjustable	1160-2270
L103	Choke, iron core, 22 µH ±10%	4300-2600
L104	Choke, iron core, 22 µH ±10%	4300-2600
L105	Choke, iron core, 22 µH ±10%	4300-2600
L106	Ferrite cup, adjustable	5000-2801
L107	Ceramic, adjustable iron core	1160-2220
L108	Ceramic, adjustable iron core	1160-2450
L201	Choke, iron core, 150 µH ±10%	4300-3810
L301	Choke, iron core, 100 µH ±10%	4300-3500
L302	Choke, iron core, 1.5 µH ±10%	4300-1000
L303	Ferrite cup, adjustable	1160-2250
L304	Choke, iron core, 15 µH ±10%	4300-2400
L305	Choke, metal, 22 µH ±10%	4300-2600
L306	Coil	1160-2280
	RESISTORS	
R101	Composition, 220Ω ±5% 1/4 W	6099-1225
R102	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R103	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R104	Composition, 47Ω ±5% 1/4 W	6099-0475

PARTS LIST (Cont)

RESISTORS (Cont)

REF NO	DESCRIPTION	PART NO
R105	Composition, 22 k ±5% 1/4 W	6099-3225
R106	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R107	Composition, 150Ω ±5% 1/4 W	6099-1155
R108	Composition, 47Ω ±5% 1/4 W	6099-0475
R109	Potentiometer, composition, 50 kΩ ±10%	6049-3508
R111	Composition, 150 kΩ ±5% 1/4 W	6099-4155
R112	Potentiometer, wire-wound, 2 kΩ ±10%	6057-2209
R113	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R114	Composition, 47Ω ±5% 1/4 W	6099-0475
R115	Composition, 82Ω ±5% 1/4 W	6099-0825
R116	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R117	Composition, 22Ω ±5% 1/4 W	6099-0225
R118	Composition, 47Ω ±5% 1/4 W	6099-0475
R119	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R120	Composition, 20 kΩ ±5% 1/4 W	6099-3205
R121	Composition, 270Ω ±5% 1/4 W	6099-1275
R122	Composition, 33Ω ±5% 1/4 W	6099-0335
R123	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R124	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R125	Composition, 330Ω ±5% 1/4 W	6099-1335
R126	Composition, 330Ω ±5% 1/4 W	6099-1335
R127	Composition, 39 kΩ ±5% 1/4 W	6099-3395
R128	Composition, 47Ω ±5% 1/4 W	6099-0475
R201	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R202	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R203	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R204	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R205	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R206	Composition, 27 kΩ ±5% 1/4 W	6099-
R301	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R302	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R303	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R304	Composition, 680Ω ±5% 1/4 W	6099-1685
R305	Composition, 330Ω ±5% 1/4 W	6099-1335
R306	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R307	Composition, 39 kΩ ±5% 1/4 W	6099-3395
R308	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R309	Composition, 220Ω ±5% 1/4 W	6099-1225
R310	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R311	Potentiometer, wire-wound, 20 kΩ ±10%	6057-3209
R312	Composition, 100Ω ±5% 1/4 W	6099-1105
R313	Potentiometer, wire-wound, 10 kΩ ±10%	6057-3109
R314	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R315	Composition, 22 kΩ ±5% 1/4 W	6099-3225
R316	Composition, 470Ω ±5% 1/4 W	6099-1475
R317	Composition, 10Ω ±5% 1/2 W	6100-0105
R318	Composition, 150Ω ±5% 1/4 W	6099-1155
R319	Composition, 820Ω ±5% 1/4 W	6099-1825
R320	Composition, 150Ω ±5% 1/4 W	6099-1155
R321	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R322	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R323	Composition, 82Ω ±5% 1/4 W	6099-0825
R324	Composition, 47Ω ±5% 1/4 W	6099-0475
R325	Potentiometer, composition, 100Ω ±20%	6040-0100
R326	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R401	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R402	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R403	Composition, 47 kΩ ±5% 1/4 W	6099-3475
R404	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R405	Composition, 330Ω ±5% 1/4 W	6099-1335
R406	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R407	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R408	Composition, 47Ω ±5% 1/4 W	6099-0475
R409	Composition, 820Ω ±5% 1/4 W	6099-1825
R410	Composition, 2.7 kΩ ±5% 1/4 W	6099-2275
R411	Composition, 330Ω ±5% 1/4 W	6099-1335
R412	Composition, 680Ω ±5% 1/4 W	6099-1685
R413	Composition, 220Ω ±5% 1/4 W	6099-1225
R414	Composition, 47 kΩ ±5% 1/4 W	6099-3475
R415	Composition, 47 kΩ ±5% 1/4 W	6099-3475

TRANSFORMERS

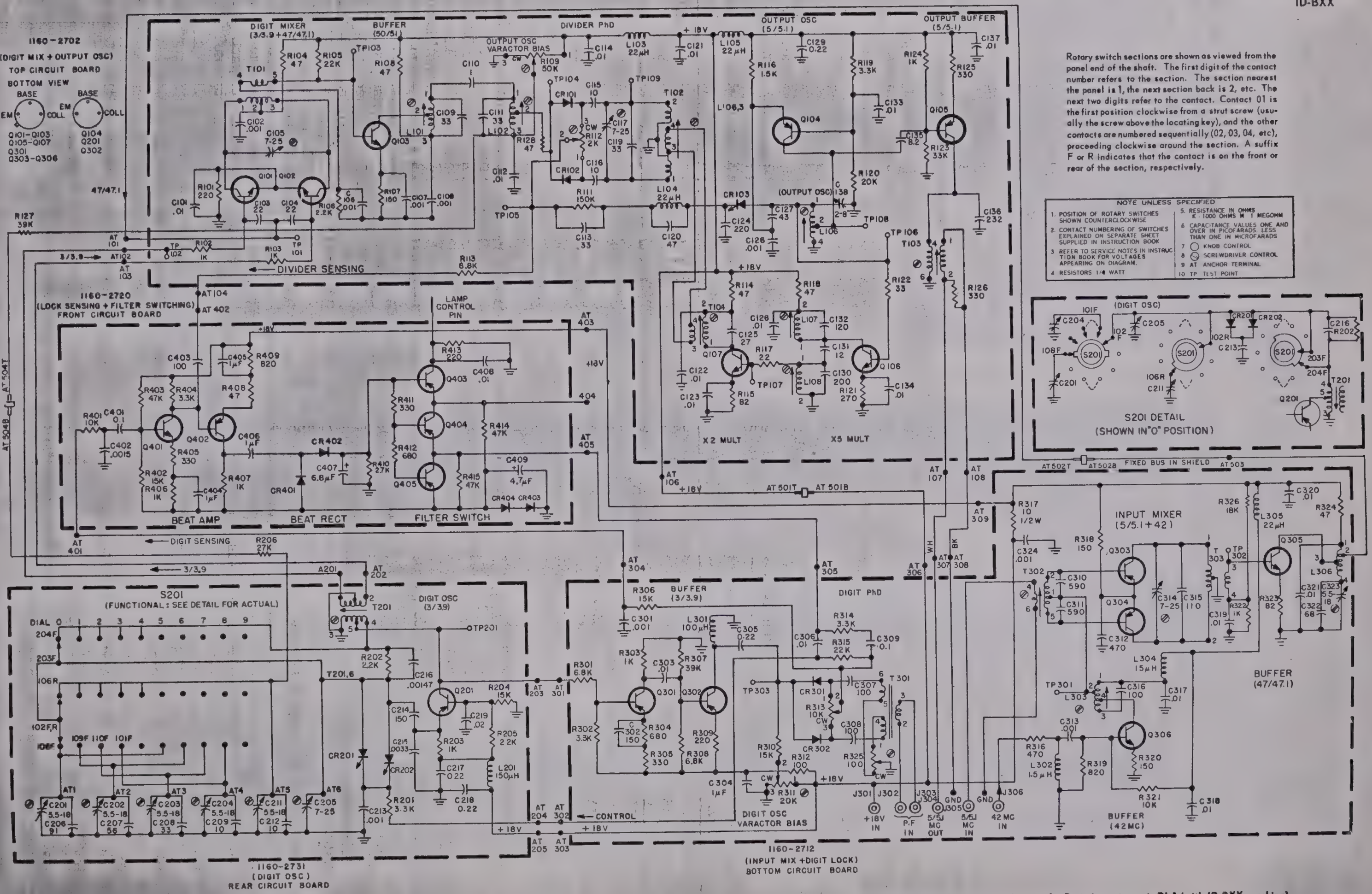
REF NO	DESCRIPTION	PART NO
T101	Ceramic, adjustable iron core	1160-2230
T102	Ceramic, adjustable iron core	1160-2210
T103	Ferrite cup, adjustable	5000-2804
T104	Ceramic, adjustable iron core	1160-2200
T201	Coil assembly, adjustable	5000-2805
T301	Ferrite cup, adjustable	5000-2803
T302	Ferrite cup, adjustable	5000-2802
T303	Ceramic, adjustable iron core	1160-2240

TRANSISTORS

REF NO	DESCRIPTION	PART NO
Q101	Type 2N708	8210-3089
Q102	Type 2N708	8210-3089
Q103	Type 2N2218	8210-1028
Q104	Type 2N3638	8210-1096
Q105	Type 2N2188	8210-1045
Q106	Type 2N2218	8210-1028
Q107	Type 2N2218	8210-1028
Q201	Type 2N3638	8210-1096
Q301	Type 2N2188	8210-1045
Q302	Type 2N3638	8210-1096
Q303	Type 2N3250	8210-1089
Q304	Type 2N3250	8210-1089
Q305	Type 2N2218	8210-1028
Q306	Type 2N708	8210-3089
Q401	Type 2N696	8210-1033
Q402	Type 2N1305	8210-1305
Q403	Type 2N1303	8210-1019
Q404	Type 2N1303	8210-1019
Q405	Type 2N1303	8210-1019

MISCELLANEOUS

REF NO	DESCRIPTION	PART NO
S201	Switch, rotary wafer, 10 position	7890-3440
J301	Jack , etched-circuit, eyelet type	1160-6110


1160-2702
(DIGIT MIX + OUTPUT OSC)
TOP CIRCUIT BOARD
BOTTOM VIEW
BASE
EM
COLL
Q101-Q103
Q105-Q107
Q301
Q303-Q306
Q104
Q201
Q302
DIGIT MIXER
(3/3.9+47/47.1)
BUFFER
(50/51)
DIVIDER PhD
OUTPUT OSC VARACTOR BIAS
OUTPUT OSC
(5/5.1)
OUTPUT BUFFER
(5/5.1)
DIVIDER SENSING
(OUTPUT OSC)
X2 MULT
X5 MULT
1160-2720
(LOCK SENSING + FILTER SWITCHING)
FRONT CIRCUIT BOARD
LAMP CONTROL PIN
BEAT AMP
BEAT RECT
FILTER SWITCH
DIGIT SENSING
3/3.9
47/47.1
S201
(FUNCTIONAL: SEE DETAIL FOR ACTUAL)
DIAL 0 1 2 3 4 5 6 7 8 9
DIGIT OSC
(3/39)
1160-2731
(DIGIT OSC)
REAR CIRCUIT BOARD
BUFFER
(3/3.9)
DIGIT PhD
DIGIT OSC VARACTOR BIAS
CONTROL
+18V
1160-2712
(INPUT MIX + DIGIT LOCK)
BOTTOM CIRCUIT BOARD
INPUT MIXER
(5/5.1+42)
BUFFER
(47/47.1)
BUFFER
(42MC)
FIXED BUS IN SHIELD
+18V IN
P.F IN
5/5.1 MC OUT
5/5.1 MC IN
42 MC IN
(DIGIT OSC)
S201 DETAIL
(SHOWN IN "0" POSITION)

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K · 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

Figure DA-9. Over-all schematic diagram for Digit Insertion unit DI-1 (with ID-BXX marking).

SECTION DA-4

DIFFERENCE DATA

DA-4.1 GENERAL.

Early production models of the DI-1 units differ in minor circuit details from present production. The external appearance and interconnection provisions with the rest of the synthesizer are identical in both versions. The only obvious distinguishing feature is the marking on the front panel of the module. Present versions bear the marking "ID-BXX", while original production had no "ID" marking. Functionally, the versions can be freely interchanged. Consequently, the preceding three sections apply equally to both versions with the exceptions noted in Section 3 and those called out below.

DA-4.2 CIRCUIT DETAILS.

The transistor types used in five stages of the original DI-1 have been changed, which has necessitated minor alterations in value for nine other detail parts, the deletion of two and the addition of three.

Resulting alterations in circuit performance (all internal) are called out specifically in the trouble-analysis procedures of paragraph DA-3.3 Other minute differences affect the dc voltage readings in the altered stages, so that a separate listing in Table DA-3 is furnished for convenience.

An abbreviated parts list, limited to specifically affected detail parts, appears below. Otherwise, the parts list given in the preceding section applies to both versions.

TABLE DA-3

TYPICAL DC VOLTAGES FOR DI-1 NOT MARKED ID-BXX

Transistor	*Emitter*	*Base*	*Collector*
Q101	1.7	-0.3	17.8
Q102	1.7	-0.3	17.8
Q103	2.1	2.4	17.7
Q104	15.0	14.7	0
Q105	17.8	17.5	0
Q106	3.0	0	17.7
Q107	1.75	0	17.2
Q201	16.2	15.7	0
Q301	11.5	11.2	5.1
Q302	15.5	15.3	0
Q303	16.6	17.7	0
Q304	16.6	17.7	0
Q305	1.00	1.37	17.0
Q306	0.7	1.30	17.7
Q401	4.0	4.7	11.3
Q402	11.5	11.2	8.5
Q403	1.1	0.90	0.73
Q404	1.25	1.05	1.1
Q405	1.3	1.10	1.25

NOTES:

Unit operating with all inputs installed in chassis, no cover.
Voltages measured with Type 1806-A direct.
These are typical readings and they are somewhat dependent on rf signal levels.
Variations of ±15% are to be expected.

PARTS LIST

(FOR DI-UNIT WITHOUT ID-BXX MARKING)

This is an abbreviated parts list that contains information on parts that differ from the parts listing given on page DA-15.

REF NO	DESCRIPTION	PART NO
C118	CAPACITOR, Mica, 0.001 μF ±5% 300 V	4700-1190
C130	CAPACITOR, Mica, 120 pF ±5% 500 V	4640-0520
C132	CAPACITOR, Mica, 82 pF ±5% 500 V	4640-0442
C136	CAPACITOR, Mica, 232 pF ±1% 500 V	4710-0411
C210	CAPACITOR, Mica, 10 pF ±10% 500 V	4620-0100
CR301	DIODE, Type 1N191	6082-1008
CR302	DIODE, Type 1N191	6082-1008
L107	INDUCTOR, Ceramic, adjustable iron core,	1160-2260
L108	INDUCTOR, Ceramic, adjustable iron core,	1160-2220
R105	RESISTOR, Composition, 12 kΩ ±5% 1/4 W	6099-3125
R109	POTENTIOMETER, wire-wound, 20 kΩ ±10%	6057-3209
R115	RESISTOR, Composition, 100Ω ±5% 1/4 W	6099-1105
R120	RESISTOR, Composition, 15 kΩ ±5% 1/4 W	6099-3155
R121	RESISTOR, Composition, 150Ω ±5% 1/4 W	6099-1155
R204	RESISTOR, Composition, 18 kΩ ±5% 1/4 W	6099-3185
R307	RESISTOR, Composition, 15 kΩ ±5% 1/4 W	6099-3155
R308	RESISTOR, Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R326	RESISTOR, Composition, 10 kΩ ±5% 1/4 W	6099-3105
Q104	TRANSISTOR, Type 2N2188	8210-1045
Q201	TRANSISTOR, Type 2N2188	8210-1045
Q302	TRANSISTOR, Type 2N2188	8210-1045
Q303	TRANSISTOR, Type 2N2188	8210-1045
Q304	TRANSISTOR, Type 2N2188	8210-1045

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

NOTE UNLESS SPECIFIED

1 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3 REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K - 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9 AT - ANCHOR TERMINAL
10. TP - TEST POINT

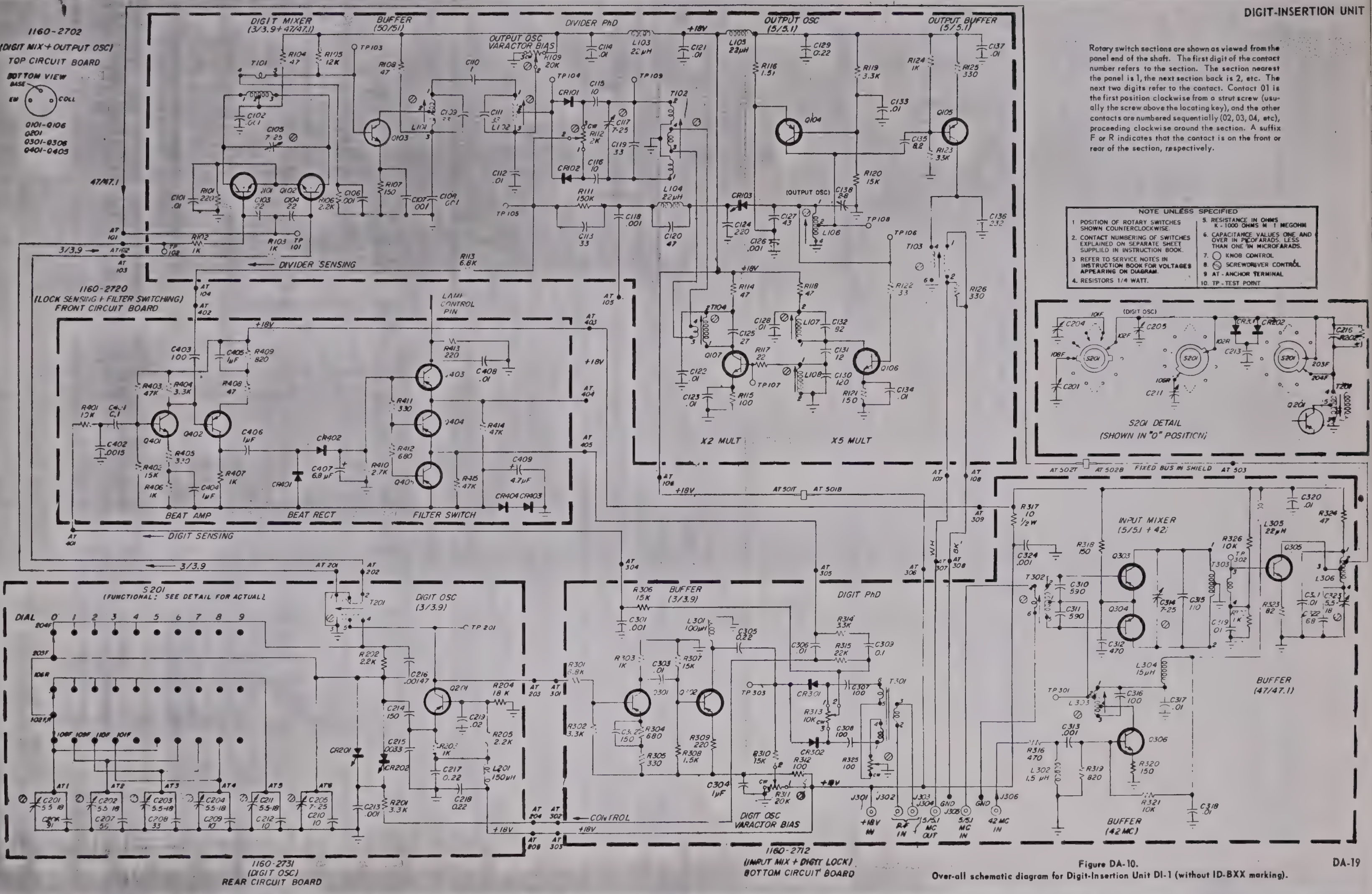

1160-2702
(DIGIT MIX + OUTPUT OSC)
TOP CIRCUIT BOARD
BOTTOM VIEW
BASE
EM
COLL
Q101-Q106
Q201
Q301-Q306
Q401-Q405
DIGIT MIXER (3/3.9+47/47.1)
BUFFER (50/51)
OUTPUT OSC VARACTOR BIAS
DIVIDER PhD
OUTPUT OSC (5/5.1)
OUTPUT BUFFER (5/5.1)
DIVIDER SENSING
1160-2720
(LOCK SENSING + FILTER SWITCHING)
FRONT CIRCUIT BOARD
LAMP CONTROL PIN
BEAT AMP
BEAT RECT
FILTER SWITCH
DIGIT SENSING
X2 MULT
X5 MULT
S201 DETAIL
(SHOWN IN "0" POSITION)
(DIGIT OSC)
FIXED BUS IN SHIELD
INPUT MIXER (5/5.1 + 42)
BUFFER (47/47.1)
BUFFER (42 MC)
S201
(FUNCTIONAL: SEE DETAIL FOR ACTUAL)
DIAL 0 1 2 3 4 5 6 7 8 9
DIGIT OSC (3/3.9)
BUFFER (3/3.9)
DIGIT PhD
DIGIT OSC VARACTOR BIAS
CONTROL
+18V
3/3.9
47/47.1
+18V IN
RF IN
5/5.1 MC OUT
5/5.1 MC IN
42 MC IN
1160-2731
(DIGIT OSC)
REAR CIRCUIT BOARD
1160-2712
(INPUT MIX + DIGIT LOCK)
BOTTOM CIRCUIT BOARD

Figure DA-10.
Over-all schematic diagram for Digit-Insertion Unit DI-1 (without ID-BXX marking).

SERVICE INSTRUCTIONS

section DB

REMOTELY PROGRAMMABLE DIGIT-INSERTION UNIT, RDI-1

P/N 1160-4005

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Form No. 1160-0110-A ID Number B189 June 1966

GENERAL RADIO COMPANY

West Concord, Massachusetts

SECTION DB-1

INTRODUCTION

DB-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section is prepared from a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis."

Included in the following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension by experienced service personnel of the principles of operation. A trouble-analysis procedure that will aid in isolation of defective circuits completes the section.

To facilitate part identification, reference designators used in the text and appearing on the photographs are the same as those used on the complete schematic diagram and in the parts list.

The service instructions rely on the use of a properly functioning synthesizer as a basic test frame for an individual module. The instrument can be used to support the module, in a convenient bench-service position, and to supply it with power and test signals.

NOTE

First consideration should be given to the use of the widespread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty.

DB-1.2 PURPOSE.

In General Radio synthesizers, output-frequency generation (remotely programmed, or in accordance with the setting of the front-panel dials) is accomplished by the modules occupying the top of the Main Frame chassis. Of these, the majority are identical and interchangeable and permit selection of crystal-locked frequencies in steps ranging from 0.01 c/s to 100 kc/s, depending on the model and the position of the module. They are called Digit-Insertion units, — DI-1 or RDI-1 for short.

Solid-state circuitry that performs this operation, with the aid of certain fixed direct derivatives of the master crystal oscillator, is self-contained in the RDI-1 package, shown in Figure DB-1. The unit is a convenient plug-in module; all connections to the Main Frame are made automatically as it is installed.

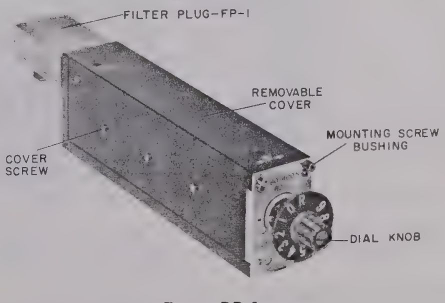


Figure DB-1.
Remotely Programmable Digit-Insertion Unit, RDI-1 (P/N 1160-4005).

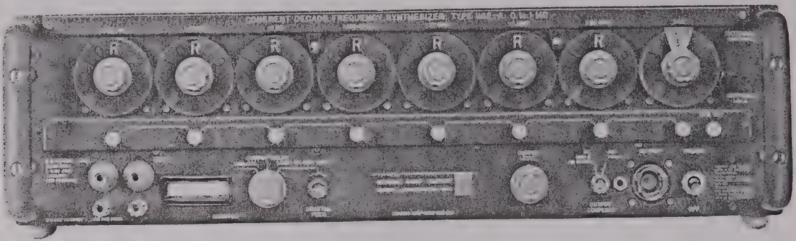


Figure DB-2.
Panel view of the Type 1162-AR7C Coherent Decade Frequency Synthesizer with all digits set for programmable operation.

The RDI-1 Digit-Insertion unit, together with its filter and matrix plug and remote cabling, permits complete or partial remote frequency programming of the GR synthesizer. The RDI-1 can be used in all DI-1 digit stations.

In all cases, it is directly and quickly interchangeable with the DI-1 unit. Control can easily be transferred digit by digit from remote to manual, by means of the front panel dial.

DB-1.3 DESCRIPTION.

The RDI-1 Digit-Insertion unit, with its cover installed, is shown in Figure DB-1. The only external operator control of the unit, the digit-selector switch, is operated by the 1/4-inch shaft and the dial knob visible in front. The ten numbered positions of the dial permit manual frequency selection. The eleventh position, marked "R," transfers control of the frequency setting to the leads in the control cable at the rear of the unit. Figure DB-2 shows a synthesizer with digit-selection controls set for remotely programmable operation.

Connections for remote frequency selection are made through the Filter Plug, FP-1, shown at the rear of the RDI-1 unit in Figure DB-1. Figure DB-3 shows the Filter Plugs connected to the rear of the programmable digit stations of a synthesizer. The Filter Plug engages a printed-circuit connector protruding through the rear wall of the RDI-1 unit and the attaching screw threads into the support bar across the back of the synthesizer.

A small plastic lamp holder, which is part of the RDI-1 as supplied, fits in the synthesizer panel behind the control knob. This holder permits installation of the dial lamp in the instrument front panel, behind the dial, after the RDI-1 has been mounted in the Main Frame (see Figure 5-2 in the systems portion of this manual).

The entire RDI-1 assembly is held in the Main Frame by two 4-40 screws that engage the threaded bushings in the top corners of its small front panel and by a hold-down clamp that secures the reinforced bottom of the cover unit at the rear, through a small cutout.

All electrical connections to the Main Frame except one are made by banana-type plugs through the bottom of the cover into the RDI-1 assembly. The dial lamp is energized and switched in the Main Frame as explained in Section 4.6 (system portion). It can also be controlled from the RDI-1, and this control-signal connection is made by a small pin in the RDI-1 front panel to a spring contact on the instrument front panel. This pin is part of a phase-error sensing circuit that extinguishes the lamp if phase lock is broken.

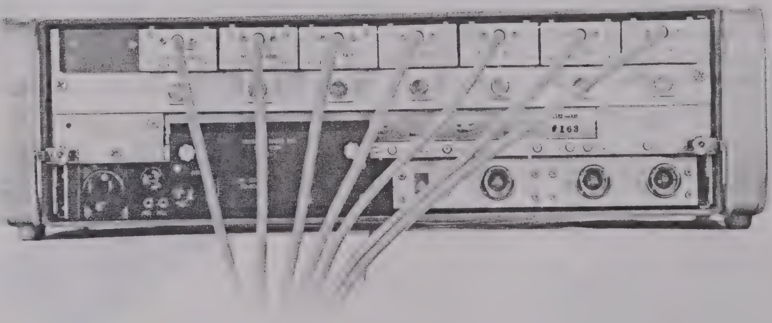


Figure DB-3.
Rear view of the synthesizer of Figure DB-2, showing plug-in filters and remote cabling.

All connections are thus established automatically when the unit is installed.

No. 4-40 screws on either side of the unit fasten the cover to the Digit-Insertion unit frame structure. After their removal, the unit can be withdrawn from the cover, if the case is held in one hand and the unit is pulled by its switch shaft with the other.

The circuitry of the RDI-1 is contained on five etched-circuit boards. They are the long horizontal top and bottom boards and the smaller vertical front and rear circuit boards. These boards mount all components and furnish most of the electrical connections between them. In the bottom board are 6 banana jacks and 2 special ground contacts, which make the electrical connections to the Main Frame mentioned earlier.

Signal flow and circuit layout are so arranged that a minimum of wiring between boards is required and each individual board assembly can be removed from the structure, after connecting-wire leads have been unsoldered and appropriate screws removed. There is, however, enough space in almost all instances to permit removal of components without board removal.

The side rails of the top and bottom boards are equipped with special ground springs to ensure intimate contact with the cover. The 7 threaded inserts, which accept the 4-40 screws that hold the cover, establish fixed contact areas between shield partition and cover. A finger-stock rf seal is used where the cover and front panel join.

DB-1.4 INSTALLATION.

DB-1.4.1 GENERAL.

If the RDI-1 unit is to be added to a synthesizer, either to convert an existing step-digit station from manual control to programmable operation, or to fill out an incomplete series of step digits, observe the procedures that follow to install the unit.

DB-1.4.2 DIGIT CONVERSION.

To convert a manual-step-digit station, proceed as follows:

a. Remove the four knurled screws on the front panel of the synthesizer (accessible through cutouts in the handles), release the two cabinet clamps at the rear of the chassis, and withdraw the instrument from its cabinet.

b. Remove the two Phillips-head screws at the ends of the dial strip, along the top of the front panel, and dismount the strip.

c. Set the DI-1 unit dial knob to "5," release the two knob set screws with a 3/32-inch Allen wrench, and remove the knob.

d. Release the screw-actuated clamp bar (mounted down on the chassis), at the rear of the module, and swing the bar out of the recess in the DI-1 cover.

e. Remove the two Phillips-head screws at the top of the dial-light assembly on the front panel.

f. Work the unit off the banana-plug attachment to the chassis, lift it clear of the plugs and draw it up and to the rear, so that the dial shaft clears the front-panel.

g. Remount the dial knob on the module and store the unit carefully.

h. Continue with paragraph DB-1.4.4.

DB-1.4.3 DIGIT COMPLETION.

To complete a partially filled synthesizer with programmable step digits, proceed as follows:

a. Perform steps a and b of paragraph DB-1.4.2.

b. Remove the screw in the lower right-hand corner of the cover plate that is installed in the unused digit station and remove the plate.

NOTE

Do not remove both screws in the cover plate, or the lamp-switching assembly, behind the panel, may become dislocated.

c. Unplug the bridging unit from the digit station.

d. Continue with paragraph DB-1.4.4.

DB-1.4.4 RDI-1 MOUNTING.

To mount the RDI-1 unit in the vacant digit station proceed as follows:

a. Make sure that the Filter Plug is disconnected from the RDI-1 module, that the dial knob is removed, and that the digit-selector shaft is set with "5" marking uppermost.

b. Insert the selector shaft through the keyhole opening in the front panel of the synthesizer, place the unit over the banana plugs protruding from the chassis in the digit station, and press down gently to engage the plugs.

c. Swing the chassis clamp bar into the recess in the rear of the module and tighten the screw there.

d. Remount the synthesizer cabinet. The procedure is the reverse of steps a through f or paragraph DB-1.4.2.

DB-1.4.5 FILTER-PLUG WIRING.

The Filter Plug, FP-1, must be wired to the external programmer. For synthesizers purchased initially with programmable digits, a 50-foot roll of special 12-wire cable is furnished. For conversions or expansions this cable is recommended as an accessory available; the catalog number is 1160-9650 (50-foot lengths). See Figure DB-4 for a completed FP-1 assembly and Figure DB-5 for cable preparation details.

To wire a Filter Plug proceed as follows:

a. Remove the three Phillips-head screws on the top of the plug assembly, to release the cover, and pull it off the unit.

b. Release the two Phillips-head screws and remove the cable-clamp-and-ferrule assembly at the rear of the plug.

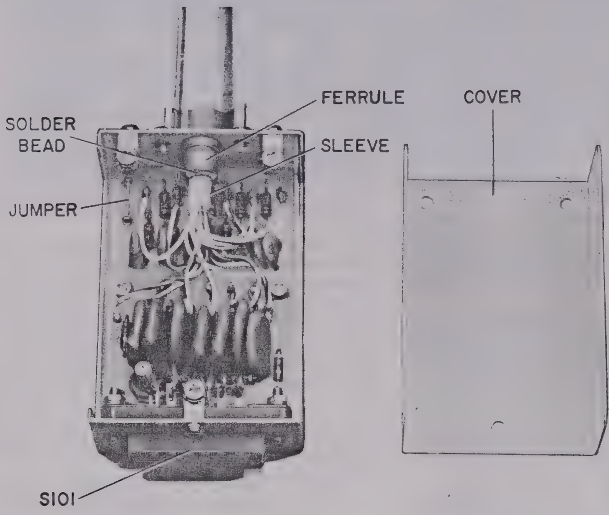


Figure DB-4.
Interior view of Filter Plug FP-1 showing remote wiring connection.

c. Remove the brass shipping clip from the clamp assembly. Carefully set aside the 3/16-inch ferrule and the 3/8-inch Teflon sleeve.

d. Insert the cable through the flanged end of the opening in the clamp, so that at least 4 inches protrudes.

e. Strip 2 1/2 inches of the grey vinyl jacket from the end of the cable, taking care not to sever the braid underneath it (see Figure DB-5).

f. Remove 2 inches of the braid, measured from the end of the cable. Take care not to unravel the Mylar sheath.

g. Expand the Teflon heat-shield sleeve just enough to allow it to pass over the Mylar sheath. Use the end of a pair of needle-nose pliers.

h. Install the Teflon heat-shield sleeve over the end of the Mylar sheath and cable, approximately 1/2 inch.

i. Pull the cable back through the clamp assembly, until the end of the jacket is 1/8-inch inside the clamp.

j. Fold the braid back over the outside surface of the clamp and trim the flared ends so that they are just short of touching the shoulder of the clamp.

k. Slip the ferrule over the end of the cable and press it over the braid, back far enough for 1/8-inch of braid to be exposed at the inside end.

l. Press the Teflon sleeve back under the clamp assembly so that no more than 1/4-inch of the sleeve is still visible.

NOTE

The ferrule should not touch the shoulder of the clamp assembly.

m. Run a solder bead completely around the inside end of the assembly to bond the ferrule to the braid and to the clamp.

n. Unravel the Mylar sheath back to the Teflon heat-shield sleeve and cut off.

o. Strip the ends of the individual leads (1/4-inch) and tin the exposed wires. Cut 1/8-inch off the ends of the tinned leads. Reinstall the completed clamp assembly in the plug.

p. Press individual leads into selected lugs and solder each one at the time of insertion. (Refer to paragraph DB-1.4.6 for sequence and lug-selection details.)

q. Dress the leads as shown in Figure DB-4. The planned slack in the leads provides service loops that permit easy alteration of the wiring at a later time, if desired.

DB-1.4.6 WIRING-CODE SELECTION.

It is recommended that the leads of the special 12-conductor cable be soldered to the lugs on the etched-circuit board of the FP-1 Filter Plug unit in order shown in Table DB-1. Note that, for the digits 0 through 8, the single color trace on the white jacket of each lead corresponds to the standard EIA color

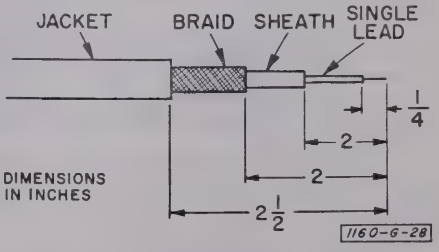


Figure DB-5.
Remote-programming control cable preparation details.

code, which should make it easier to keep the program code in sequence at the other end of the cable.

The white-with-blue-black-trace lead should be soldered to the lug marked COM, to complete the digit-selection wiring.

The two remaining leads should be soldered to lugs as indicated in the table, even if there is no planned use of external power for programmed digit selection.

TABLE DB-1

CONTROL-CABLE CONNECTION
(See Figures DB-4 and DB-18)

Lug Marking	*Lead Identification*
0	White with black trace
1	White with brown trace
2	White with red trace
3	White with orange trace
4	White with yellow trace
5	White with green trace
6	White with blue trace
7	White with violet trace
8	White with grey trace
COM	White with blue/black trace
EXT +	White with blue/brown trace
EXT -	White with black/brown trace

DB-1.4.7 FINAL INSTALLATION.

To complete the installation of a programmable-digit station, proceed as follows:

a. Reinstall the cover and plug the FP-1 on the printed-circuit connector protruding through the rear of the RDI-1 unit.

b. Thread the clamp screw on the bottom of the plug into the tapped hole in the support bar at the rear of the synthesizer and finger tighten.

c. Select an adequate length for the cable to reach the programmer and cut the cable. Attach it to the programmer, observing the color-code selections indicated in paragraph 1.5.

NOTE

The 4-inch length of aluminum channel stock supplied with the plug is a clamp-screw extender that is required only when the plug is to be used on a Type 1164 Synthesizer.

To allow for greater chassis depth of the Type 1164 Synthesizer, the extender rod should be installed in place of the swivel-mounted clamp screw on the bottom of the Filter Plug. The cutaway end attaches to the plug. Then, if the nut is remounted on the bottom of the rod at the other end, the Filter Plug can be affixed to the support bar across the rear of the synthesizer.

DB-1.5 OPERATION.

DB-1.5.1 GENERAL.

The selection of an RDI-1 digit frequency, from a remote location connected to the synthesizer by wires, is accomplished by establishing connections between these wires. As long as the dial of the RDI-1 unit is set to one of the digits 0-9, the digit frequency corresponding to this local selection is generated regardless of any existing remote-wire connection. In the "R" dial position, control of frequency is transferred to the output terminals of the FP-1 unit, from which point it may be extended as desired.

For programmed operation, the unit can be controlled by either a 10-line or a biquinary code. Digit selection can be accomplished by closure between wires by contact, by transistor switch, or other suitable means. Switching power is internally supplied normally, but provision is made for an external supply, rated at 20 Vdc, 10 mA. The time interval occuring between contact closure and the presence of a newly selected frequency is 2 ms, maximum.

DB-1.5.2 TEN-LINE OPERATION.

In the ten-line mode each digit selection is made by one closure only, consequently 10 wires (one COMMON and 9 digit leads) are required. The FP-1 is normally supplied wired for 10-line operation with the jumper AT104-AT105 installed. The code is listed Table DB-2 — all closures are to the common lead.

TABLE DB-2

TEN-LINE CONNECTION CODE FOR
FP-1 FILTER PLUG
(See Figures DB-17 and DB-18)

Digit \ *Solder Terminal*	0	1	2	3	4	5	6	7	8
9									none
8									x
7								x	
6							x		
5						x			
4					x				
3				x					
2			x						
1		x							
0	x								

x = Connect terminal to COM to actuate digit.

DB-1.5.3 BIQUINARY OPERATION.

The biquinary mode of operation affords remote control with the least number of wires. One remote common lead, one shift (or HI-LO) lead and four digit leads are all that are required. The code is listed below in Table DB-3; all closures are to the COM lead.

NOTE

Jumper AT104-AT105 must be removed when this mode of operation is desired. This jumper is located near the back (cable) end of the filter plug, see Figure DB-4.

TABLE DB-3

BIQUINARY CONNECTION CODE FOR FILTER PLUG FP-1

(See Figures DB-17 and DB-18)

Digit *Solder Terminals*	0	1	2	3	4	5	6	7	8	9
COM	x	x	x	x	x	x	x	x	x	
8									x	
7								x		
6							x			
5						x				
4	x	x	x	x	x					
3				x						
2			x							
1		x								
0	x									

x = terminals to be connected.

DB-1.5.4 EXTERNAL RELAY POWER.

When the RDI-1 reed-relay coils are powered from the internal power supply, the open digit leads are at a potential of +18 Vdc and the COMMON lead is near instrument ground. Where these potentials are not compatible with external circuitry, they may be shifted by the use of an external supply. Filter-capacitor working voltages restrict the range to plus and minus 50 Vdc with respect to instrument ground. The diode matrix requires the polarity indicated, i.e., the positive side of the supply must be connected to the "EXT+" terminal and negative side to the "EXT-" terminal. The limits of potentials at the "EXT" terminals are given in Table DB-4.

TABLE DB-4

EXTERNAL VOLTAGE RANGES FOR FP-1

Terminal	*Range*
EXT +	+50 to -30
EXT -	+30 to -50

Before attempting to operate the reed relays on external power, the two jumpers A-C and D-F on PL601 (back of RDI-1) have to be removed by clipping or unsoldering.

NOTE

The externally supplied relay power will be required for both remote and local control.

To cover the drop on the extra filtering for external power, 20 Vdc is the suggested operating voltage for the external reed-relay power.

DB-1.5.5 ELECTRONIC KEYING.

Where mechanical contacts are not desired, the reed-relay circuits may be closed by transistors or any other suitable electronic device. Saturated operation is suggested to keep the drop in the switch below 0.5 Vdc. Where a larger drop cannot be avoided, the currents on the leads should be measured. Currents for safe operation are given in Table DB-5.

TABLE DB-5

SAFE CURRENTS FOR RELAY CLOSURE

Digit	*Current (mA)*
8, 7, 6, 5,	3
4	6
3, 2, 1, 0 (10 line)	9

When currents called for in Table DB-5 cannot be obtained, external power for the reed relays may be used with a potential of more than 20 Vdc; neither side of the external power supply, however, can have more than 50 Vdc against instrument ground.

SECTION DB-2

PRINCIPLES OF OPERATION

DB-2.1 GENERAL.

The main circuits of the RDI-1 are shown in the block diagram, Figure DB-6 (see also the full schematic diagram, Figure DB-16).

In accordance with the flow in the synthesizer itself, where the signal is fed from DI-1 to DI-1 (from right to left), the main signal flow in the block diagram is from right to left, along the horizontal axis of the figure.

Ancillary signals, which are used in common by all DI's, consist of the 42-Mc signal to the Input Mixer and the Picket-Fence input to the Digit Phase Detector. These signals are supplied by the AFS unit (Section CA), from common busses in the Main Frame chassis (Sections BA, BB).

Operating frequencies, or frequency bands, are indicated inside the blocks of the diagram. Above the blocks, frequencies that would result from an arbitrary input frequency of 5.069 Mc/s and a digit selection of 5 are indicated as an example.

A simple numerical example will serve to explain this operation:

Since (from paragraph 4.4)

$$f_{out} = f_c + \frac{f_{s_{in}}}{10} + 10d \qquad \text{kc/s}$$

and if

$$f_{s_{in}} = f_{in} - f_c$$

so that

$$f_{out} = f_c + \frac{f_{in} - f_c}{10} + 10d,$$

with

$$f_{in} = 5069 \qquad \text{kc/s}$$

and

$$d = 5 \text{ (digit setting)},$$

then

$$f_c = 5000.0 \qquad \text{kc/s}$$

$$\frac{f_{in} - f_c}{10} = 6.9 \qquad \text{kc/s}$$

$$10d = 50.0 \qquad \text{kc/s}$$

with the result that

$$f_{out} = 5056.9 \qquad \text{kc/s}$$

From the comparison of f_{in} and f_{out}, it is obvious that in f_{out} a "5" has been ***inserted*** between the 0 and 6 of the input frequency.

DB-2.2 SIGNAL FLOW.

The input signal, 5.069 Mc/s in the example, reaches the Input Mixer through a fixed-tuned transformer. The amplified 42-Mc signal from the AFS is added here and the upper sideband is selectively amplified in the following buffer. This signal of 47.069 Mc/s is fed into the Digit Mixer, where a 100-kc multiple between 3.0 and 3.9 Mc/s is added. This "digit" signal comes from the Digit Oscillator, which is phase-locked to a particular component in the Picket Fence, as described below.

The number following the decimal point in the Digit-Oscillator frequency (in Mc/s) is the same as the number to which the digit-selector dial has been set, so that 3.0 Mc/s corresponds to "0", 3.1 Mc/s to "1", and so on. If, as in this example, the dial has been set to digit "5", then 3.5 Mc/s is added to 47.069. The resulting upper sideband of this mix is 50.569. This signal is filtered, amplified, and fed into the Divider Phase Detector.

The remainder of the main signal circuit produces, in effect, a division by 10 and as a result the

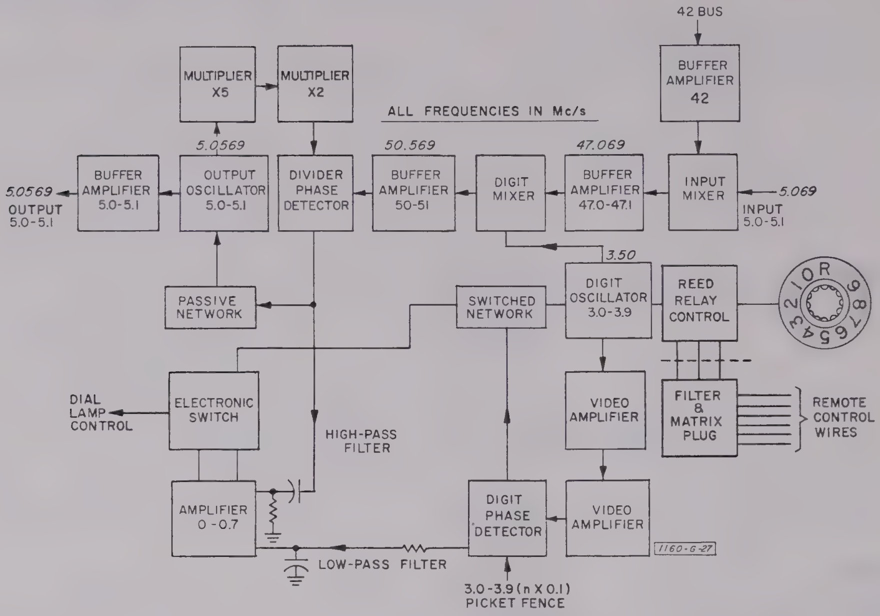

42 BUS
BUFFER AMPLIFIER 42
MULTIPLIER X5
MULTIPLIER X2
ALL FREQUENCIES IN Mc/s
5.0569
50.569
47.069
5.0569
OUTPUT 5.0-5.1
BUFFER AMPLIFIER 5.0-5.1
OUTPUT OSCILLATOR 5.0-5.1
DIVIDER PHASE DETECTOR
BUFFER AMPLIFIER 50-51
DIGIT MIXER
BUFFER AMPLIFIER 47.0-47.1
INPUT MIXER
5.069
INPUT 5.0-5.1
3.50
PASSIVE NETWORK
SWITCHED NETWORK
DIGIT OSCILLATOR 3.0-3.9
REED RELAY CONTROL
O R 9 8 7 6 5 4 3 2 1
DIAL LAMP CONTROL
ELECTRONIC SWITCH
HIGH-PASS FILTER
VIDEO AMPLIFIER
FILTER & MATRIX PLUG
REMOTE CONTROL WIRES
AMPLIFIER 0 -0.7
DIGIT PHASE DETECTOR
VIDEO AMPLIFIER
1160-G-27
LOW-PASS FILTER
3.0-3.9 (n X 0.1) PICKET FENCE

Figure DB-6.
Simplified block diagram for Remotely Programmable Digit-Insertion Unit.

Output Oscillator is now set to 5.0569. This frequency is amplified and appears at the output terminal of the RDI-1. If we compare the input and output frequencies, we note that the "69" digits in the input have been shifted to the right by one position and that a 5 has been inserted in front of them. This is the general process, which is implemented as shown by the other blocks in the diagram.

On the top right-hand side of the diagram, there is a tuned 42-Mc amplifier that takes a signal from a 42-Mc bus (generated by the AFS), amplifies it, and injects it into the balanced mixer. The main purpose of this amplifier is to provide isolation between the 42-Mc bus in the Main Frame and the Input Mixer. The 47+ signal without such isolation could enter other DI units and create spurious products.

The Digit Mixer 3.0 – 3.9-Mc input signal comes from the step-tuned Digit Oscillator, which, through amplifiers, feeds one input of the Digit Phase Detector. The reference input to this Phase Detector is the Picket Fence, consisting of a group of 100-kc standard-frequency multiples lying between 3.0 and 3.9 Mc/s. This group of signal frequencies of equalized amplitude is also supplied by the AFS.

The Phase-Detector output controls the oscillator frequency by means of varactor diodes. This phase-lock loop locks the Digit Oscillator to a frequency controlled by the primary crystal oscillator in the AFS. The Digit Oscillator is tuned approximately to one of the ten frequencies by reed relays that switch in various combinations of trimmer capacitors. The reed relays are energized either via remote wire connections or internally by a rotary switch. For the ten frequencies, the Digit Oscillator employs a tracking scheme that minimizes the number of capacitive trimmers and adjustments required. To the tuned-element sets used for the five higher frequencies, two padders are added so that the lower five frequencies fall into place with only one adjustment. Mistracking, when equalized, is 2 kc/s maximum.

Division by 10, from 50+ Mc/s to 5+ Mc/s, is achieved with phase lock in subsequent stages. The Output Oscillator signal is multiplied by 5, then by 2, and fed into a phase detector, the other side of which is fed by the filtered Digit-Mixer output frequency (in the example, 50.569 Mc/s). The Output-Oscillator frequency is varactor-controlled by the Divider-Phase-Detector output and, therefore, the frequency of the oscillator in the locked condition is one-tenth the reference frequency from the Digit Mixer.

From Figure DB-6 it can be seen that the two phase detectors have output connections to a 0 – 0.7-Mc amplifier, through high- and low-pass filters. The amplifier feeds an electronic switch. As long as ac signals in the passband of the filters are present, the switch is open and the bandwidth of the switched network is wide. This is the condition prior to capture; after capture, the ac components disappear, the switch closes, and the bandwidth is narrowed. Reduction of bandwidth is necessary in the digit phase lock, where all pickets are present simultaneously to minimize 100-kc spurious sidebands. "Capture" is indicated by the dial light, which is extinguished if either oscillator fails to lock.

DB-2.3 CIRCUIT DETAILS.

DB-2.3.1 GENERAL.

Circuits, and the location of prominent components, will be discussed in the sequence in which the signal passes through a Digit-Insertion unit. Reference will be made to the block diagram Figure DB-6, as well as the over-all schematic diagram, Figure DB-16. Figure DB-7 will be a useful reference for physical identification of the circuits discussed.

DB-2.3.2 INPUT SECTION.

The input section consists of an Input Mixer preceded by a 42-Mc Buffer and followed by a 47 – 47.1-Mc Buffer. The 42-Mc Buffer is a common-emitter stage, Q306, with a tuned output coil, L303, that serves as isolator, amplifier, and impedance transformer for the 42-Mc signal from the AFS. This signal is taken from the 42-Mc bus, through J306, and processed for injection at the Input Mixer. The input network of the buffer is of moderately high impedance and is broadly tuned.

The Input Mixer combines the incoming 5.0 – 5.1-Mc signal from J305 and the 42-Mc signal from the buffer. The 5.0 – 5.1-Mc input, of approximately 0.30 V, is stepped up in T302 and applied to Q303 and Q304. The connection between L303 and T302 feeds the 42-Mc signal to the transistors in-phase and also completes the bias circuit. The balanced configuration, together with the circuit (T303, C314, C315) tuned to the upper sideband (47 – 47.1 Mc/s), effectively eliminates the 42-Mc component in the output and provides substantial rejection for the ninth-harmonic component of the 5 to 5.1-Mc input signal.

Q305 is a transformer-coupled buffer-amplifier which amplifies the 47 – 47.1-Mc signal for application to the Digit Mixer. Tuned output coil L306 further contributes to the selectivity provided for the suppression of unwanted mixer-output components.

The input circuits described above occupy the front right-hand side of the bottom circuit board (see Figure DB-7).

DB-2.3.3 DIGIT MIXER AND 50 – 51-Mc BUFFER.

Wire links, joined through the central shield partition by AT502, bring the 47 – 47.1-Mc signal from the Q305 buffer stage to C103 and C104 (at the rear of the top board), which form the input to the Digit Mixer. The second signal into this mixer is the Digit-Oscillator output of 3.0 – 3.9 Mc/s, in 100-kc steps. The resultant output of 50 – 51 Mc/s (47 + 3.0 to 47.1 + 3.9 Mc/s) is filtered in the tuned circuit T101/C105 and applied to the following buffer, Q103. To obtain an equalized output over the 1-Mc bandwidth, a double-tuned filter (compensating the response of the preceding single-tuned circuit) couples the signal into the Divider Phase Detector.

The Digit Mixer and Buffer circuits are located on the top board at the back end (see Figure DB-7).

DB-2.3.4 OUTPUT OSCILLATOR/MULTIPLIER.

The output signal of 5.0-5.1 Mc/s is generated in a Colpitts oscillator (Q104). The tuned circuit includes the varactor diode, CR103, which makes the oscillator voltage-tunable.

Transistors Q106 and Q107 perform the multiplication of the oscillator frequency by ten. Both are class-C multipliers that are tuned to the desired harmonic of the input frequency in the respective collector circuits. L107/L108 are resonated at approximately 25.25 Mc/s and T104/T102 are tuned to about 50.5 Mc/s.

The above circuits, from the oscillator through the multipliers into the Divider Phase Detector (a conventional half-bridge circuit), and from its output through filter circuits back to varactor-diode CR103, form a phase-lock circuit. Once captured, the oscillator frequency is kept at exactly 1/10th the reference frequency (50-51 Mc/s) by a dc voltage applied to the varactor diode. This voltage is developed in the phase detector.

If a different dc voltage is required on the varactor diode, to compensate for circuit drifts in the oscillator for instance, only the relative phases of the two inputs to the phase detector change. Potentiometer R109 sets the initial back-bias for the varactor diode and, therefore, affects the free-running oscillator frequency.

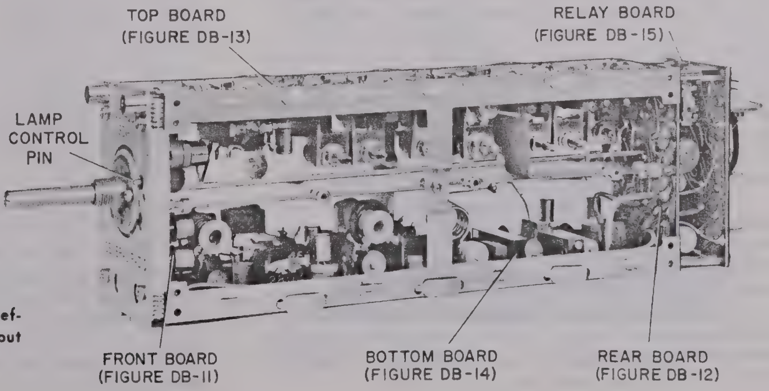

TOP BOARD (FIGURE DB-13)
RELAY BOARD (FIGURE DB-15)
LAMP CONTROL PIN
FRONT BOARD (FIGURE DB-11)
BOTTOM BOARD (FIGURE DB-14)
REAR BOARD (FIGURE DB-12)

Figure DB-7.
RDI-1 module with cover off. Referenced figures give circuit-layout details.

During the process of capture (the synchronization of the oscillator frequency with the reference frequency), the oscillator is frequency-modulated initially with the frequency difference between the reference and its own frequency multiplied by ten. Sidebands of this modulation have to be passed by the multiplier circuits and they are therefore considerably wider in bandwidth than the 5-5.1 or 50-51 Mc/s would suggest.

The Output Buffer, Q105, is a broadly tuned, common-emitter stage following the oscillator. The output voltage of approximately 0.30 V, rms, is fed to J304. Note that the contact associated with J304, as well as the contact near the input (J305), is not internally grounded. Ground springs on the Main Frame connect both the output and input ground contacts of adjacent DI-1 units. The fact that the springs are connected to the chassis in only one place increases the isolation of the input and output circuits, since the chassis has to carry no current.

The Output Oscillator, Output Buffer, and multipliers are located in the front half of the top circuit board (Figure DB-7).

DB-2.3.5 DIGIT-OSCILLATOR PHASE LOCK.

The Digit Oscillator provides injection frequencies to the Digit Mixer, which are the crystal-locked 100-kc steps between 3.0 and 3.9 Mc/s. While all of these frequencies are present simultaneously in the Picket Fence (generated in the AFS), only one specific frequency is required for each setting of the digit-selector dial (S201). All others must be kept out of the Digit Mixer, in order to avoid spurious outputs. The selection and filtering of the proper Picket-Fence frequency is achieved by a step-tuned oscillator and a phase-lock loop.

Colpitts-oscillator Q201 is tuned to each of the ten frequencies by relay-selected trimmer capacitors, C201 through C205. C205 is always connected and is used alone to adjust the 3.9-Mc top frequency initially (digit-selector setting 9). Digits 8, 7, 6, and 5 are set by C204, C203, C202, and C201, in that order. At this midband point, a pair of padder capacitors (C211 and C212) is added as shown to select digit 4 and the lower digits. After adjustment of the 3.4-Mc frequency with C211, the lower frequencies are obtained automatically with the same trimmer-capacitor settings used for the corresponding higher frequencies. The circuit inductance, T201, is preadjusted to the proper value so that tracking errors are kept below ±2 kc/s. As in the Output Oscillator, part of the C in the tuned circuit is represented by voltage-variable capacitance (CR201 and CR202), to obtain phase-lock capability.

Reed-relay coils K601L to K605L are all connected to the positive (+18 Vdc) supply on one side; completion of the circuit to ground from the other end of the coil will close the relay contact and select a particular digit. S601 closes these circuits in positions 0-9. In the "R" position the "REMOTE COMMON" lead is grounded, so that relay coils may be energized by connection of a digit wire to the REMOTE COMMON lead externally.

To avoid signal radiation and cross-coupling, remote wires are passed through filter plug FP-1 before leaving the instrument. Housed in the same enclosure is the diode matrix used to convert from the biquinary to a 10-line code (see Figure DB-18).

Two video-amplifier stages, Q301/Q302, amplify the oscillator signal for injection into the Digit Phase Detector. The reference side of the phase detector is transformer-connected (T301) to the balanced Picket-Fence bus in the Main Frame. The phase-detector control-signal output is filtered and applied to the varactor diodes, CR201 and CR202. If the Digit-Oscillator free-running frequency deviates from the chosen crystal-derived Picket-Fence frequency, the phase of this oscillator signal shifts, until the phase detector produces enough dc output to correct the oscillator frequency by means of the varactor diodes.

Picket frequencies to which the oscillator is not locked produce 100-kc, 200-kc, etc, outputs from the phase detector that would frequency modulate the oscillator, if not suppressed. Consequently, sufficient attenuation of these signals and retention of adequate capture range are conflicting requirements. The filter, in the "CONTROL" line between the phase-detector output and the oscillator varactor diodes, therefore, operates in two modes, as selected by the filter-switching circuit (Q403-Q405). The filter passband is wide for the capture process and narrow for normal operation, after capture has been attained. The normal back-bias for the varactor diodes is established by potentiometer R311.

The RDI-1 output frequency changes 10 kc/s for every 100-kc step of the Digit Oscillator or 90 kc/s for the total Digit-Oscillator range of 900 kc/s, because of the division-by-ten following the Digit Mixer. The 100-kc range, from 5.0-5.1 Mc/s in the input frequency, is reduced to 10 kc/s in the output for the same reason. This means that 90% of the signal supplied as reference to the Divider Phase Detector comes from the Digit Oscillator and only up to 10% from the input signal.

Thus, the Digit Oscillator setting can be used to preset output-oscillator tuning in the correct general region for easy capture. The feedthrough (via AT504) from the Digit Oscillator through R206 and R127, to the arm of R109, shifts the free-running frequency of the Output Oscillator. By variation of the dc bias on the varactors, it is shifted from approximately 5.025 Mc/s (for digits 0 through 4) to approximately 5.075 Mc/s for digits 5 – 9.

The Digit Oscillator is located on the rear board, while the two video stages and the Digit Phase Detector occupy the rear half of the bottom board (see Figure DB-7).

DB-2.3.6 LOCK SENSING AND FILTER SWITCHING.

Capture of the two phase-lock loops, the divider main loop and the digit-oscillator loop, is monitored by the lock-sensing and filter-switching circuit. The input amplifiers, Q401 and Q402, are connected to the phase detectors to amplify ac output signals present. Any two signals that enter the phase detectors without achievement of lock will produce an ac output that corresponds to their frequency difference. This output is applied to the voltage-doubler-rectifier, CR401/CR402, and is used to cut off transistors Q403 through Q405. This will (in turn through the lamp-control pin) extinguish the dial lamp on the front panel, to give warning of malfunction.

In the normal condition of this switch, stages Q403 through Q405 are turned on, effectively shorting C306 in the filter network that follows the Digit Phase Detector. This effect introduces a low-frequency cutoff network (R315, C306) and lowers the loop gain by the loading of the phase-detector output with R314.

If the Digit Oscillator is now switched to a new frequency (which might be slightly off from the crystal-derived Picket Fence) the beat note, through R306-R401, will be applied to the amplifiers and open the switch. This will unground C306 and thereby shunt R315 with R314. The bandwidth is widened, the load is removed from the phase detector, and capture can now be attained. As the beat note disappears from the phase-detector output after capture, the switch will return to the normal, closed position.

R306/C301 and R401/C402 form a low-pass filter to prevent the 100-kc beat note, which is always present in the Digit Phase Detector due to adjacent pickets, from opening the switch.

DB-2.3.7 DIGIT-SELECTION CIRCUITS.

The RDI-1 dial has an 11th position marked R, in which frequency selection is made by contact closure on remote leads. If the dial is moved from the R position, manual selection overrides.

Selection of a digit in the RDI-1 is accomplished by the change of frequency in the Digit Oscillator. Capacitors in that circuit are switched by low-loss, rf-type reed relays. The reed driver coils are energized from the internal supply but can also be operated from an external supply. To select a particular digit, establish connection between the designated digit wire and the common lead.

A magnetic reed relay is a normally open reed switch, surrounded by a small electromagnetic drive coil. The reed switch is a glass capsule, containing two permeable reeds in a nitrogen atmosphere. When the drive coil is energized, the reeds snap closed. Coil actuation is limited to low-ripple-current dc.

The inherent simplicity of the dry-reed-switch structure is one key to its long life and reliability. The switch consists of two reeds, of a ferro-magnetic material, inserted into opposing ends of a glass tube in a cantilever fashion. The internal ends of the reed are overlapped, the glass envelope is fused to the reed shanks, and a fixed air gap is established between the cantilever beams. The sealing process is performed in the presence of dry inert gas to ensure contact operation free from surface contamination and oxidation. In use, when a magnetomotive force is applied by the coil the reed becomes a flux-carrying element in the magnetic circuit. The contact ends assume opposite polarity and snap together, closing the switch.

The reed relays are directly associated with rf circuitry in the digit oscillator. An internal two-section filter is used to reduce rf voltages on the remote wiring, to approximately 50 μV. In addition, the recommended cable has a grounded shield to prevent RFI.

The components of this filter are housed in a small, separate, plug-in shield engaging a connector that protrudes from the rear of the RDI. This filter plug also contains the diode matrix that facilitates conversion from an internal biquinary code to a 10-line code. The unit can be remotely programmed in either code; the filter plug is normally wired for 10-line, but removal of one jumper wire converts it to the biquinary code.

In the latter mode of operation, the digit 9 is produced with no external closures; 8, 7, 6, 5 are selected by connection of the appropriate wire to the common wire. The lower digits 4, 3, 2, 1, 0 are obtained with the same closures used already for the higher digits but with the additional closure of a range (or shift) wire to common. The 8 wire produces digit 3 when connected to common, 7 selects digit 2, and so on. In the 10-line mode, where one wire corresponds to each digit, the digit 9 is also selected with no closures. The 12 leads in the cable supplied are the maximum needed (10-line with external power).

A device is suitable for direct connection to the RDI-1's if it provides either mechanical or electrical contact closure in the 10-line or biquinary form and maintains continuous closure as long as a particular frequency setting is desired.

If a transistor switch is used, voltage drop must not exceed 0.5 volt for currents from 3 to 9 mA. The internal supply places the common lead at ground potential, whereas the open leads are at +18 volt with respect to ground.

For operation with external supply, two jumper wires must be removed. This should facilitate direct tie-in with existing equipment, particularly with transistor-switch outputs.

Programming by digital equipment in binary-coded decimals may require external storage, if entry is in serial rather than in parallel form.

Reed-relay switching time is within 2 milliseconds. This is the time interval between the external contact closure and the presence of the newly selected frequency. The actual transition from one frequency to another can be appreciably faster as seen in Figure DB-8, which shows a switch from 9.0924 kc/s to 2.0361 kc/s. The heavy trace is the voltage across the external contacts (of the first digit). The lower portion shows closed contact (0 volts) and the upper portion open contact. Time scale is 2 ms/cm.

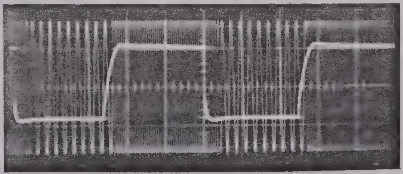


Figure DB-8. RDI-1 output-frequency switching-time capability.

SECTION DB-3

SERVICE AND MAINTENANCE

DB-3.1 INTRODUCTION.

If the system self-check procedures of Section 5 (front part of the manual) indicate that service is required for an RDI-1 unit, remove the unit from the chassis (paragraph 5.4.2) and replace it with a bridging unit (paragraph 5.5.1).

It is recommended that the unit be returned for service to the General Radio Company (particularly within warranty). Where this is not possible, certain tests can be made in the field, but a thorough understanding of the principles of operation is essential (refer to Section DB-2 above).

The procedures that follow will permit isolation of the fault, so that corrective measures can be taken. Since the synthesizer Main Frame can be used as a test fixture, refer to the appropriate Main Frame chassis schematic (Section BA or BB), as well as to the over-all schematic for the unit, Figure DB-16.

NOTE

Reference is made to banana plugs and other test points on the Main Frame by the designations used in Chassis 1160-4060.

DB-3.2 TEST EQUIPMENT.

Table DB-6 lists recommended test equipment required to test the RDI-1 module. Equivalent equipments may be substituted.

DB-3.3 TROUBLE ANALYSIS.

DB-3.3.1 GENERAL.

CAUTION

Turn power off during set-up changes to avoid accidental short circuits, which can blow F503 in the Power Supply module (PS-1).

Remove the malfunctioning RDI-1 unit from the Main Frame and withdraw the unit from its cover, after removal of the three 4-40 screws on each side. Reinstall the open unit (complete with dial lamp) carefully in station VII, next to the CAD unit. Do not install Filter Plug FP-1. Remove the CAD unit, as in paragraph 5.4.3 (front part), as well as the DI unit in station VI. Do not install a bridging unit in this space. The Calibrating Mixer module does not have to be removed.

Use Figures DB-9 and DB-10 to locate interior test points, which for the most part are simple wire loops in the top circuit board of the unit.

DB-3.3.2 POWER INPUT.

With the VTVM look for +18 ±0.2 Vdc at AT205 on the rear circuit board. If the indication is abnormal, check the distribution of this supply voltage in the Main Frame chassis and this output of the Power

TABLE DB-6
TEST EQUIPMENT

Function	*Type Recommended*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806 (with 1806-P1 probe)	BW 1-55 Mc/s; sensitivity 0.2 V; probe capacity 2.0 pF maximum
Digital Frequency Meter	GR 1143 or 1144	Dc to 50 Mc/s; resolution 100 c/s; sensitivity 0.1 V; input impedance >500 ohms
Oscilloscope	Tektronix 543 (with C/A plug-in and P6006 10× probe)	20 Mc/s, 0.5 V/cm, 8 pF (or less) probe.

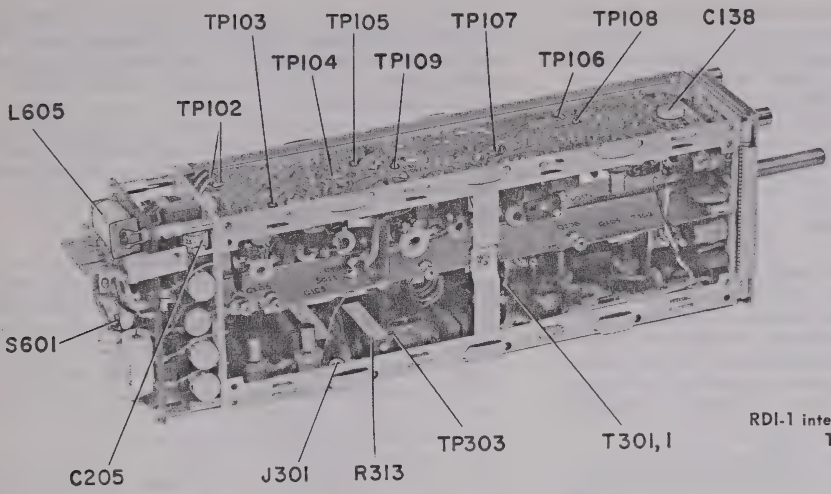


Figure DB-9.
RDI-1 interior test points and adjustments
Top left oblique view.

Supply module. If the indication is normal, continue with the procedures below.

DB-3.3.3 OUTPUT OSCILLATOR/OUTPUT BUFFER.

Connect the oscilloscope or the VTVM between PL212-6 and the ground spring on the top deck of the Main Frame, to the left of the RDI-1 under test. Depress the CAD OFF button and turn the POWER switch on. An rf voltage of 0.2 to 0.4 V, rms, should be present. If no indication is obtained, or if inadequate voltage is observed, the Output-Oscillator (Q104),or the Output-Buffer (Q105) circuit,is probably faulty.

DB-3.3.4 PHASE-LOCK LOOP TESTS.

If the proper output voltage was present in the preceeding test, confirm that an input signal to the RDI-1 under test is present at PL213 on the Main Frame top deck. This should be about 0.3 V, rms, at 5.0 Mc/s.

Then, connect the digital frequency meter to PL212-6 (connects with J305 on RDI-1) and observe the output frequency corresponding to various dial positions of the DI unit. A properly functioning unit would indicate 5.0100 Mc/s for digit 1, 5.0200 Mc/s for digit 2, and so on. If steps of nearly (but not exactly) 10 kc/s are obtained, the main loop is functioning properly, but the digit-oscillator loop is not locked.

If, however, the frequency does not move in steps of exactly 10 kc/s in accordance with the dial, or if only certain of the frequencies (like 5.0500 Mc/s for digit 5) are obtained exactly and others are off, the main loop is out of order. (Operation of the digit phase-lock loop cannot be tested at the output of the DI unit, where the counter is connected, as long as the main phase-lock loop is out of order).

Indications of the dial lamp will permit further conclusions about the two phase locks. If the dial lamp is extinguished while an improper frequency is shown, both signals into the Divider Phase Detector are present but they are not locked. This may be due to low signal level or to improper free-running os-

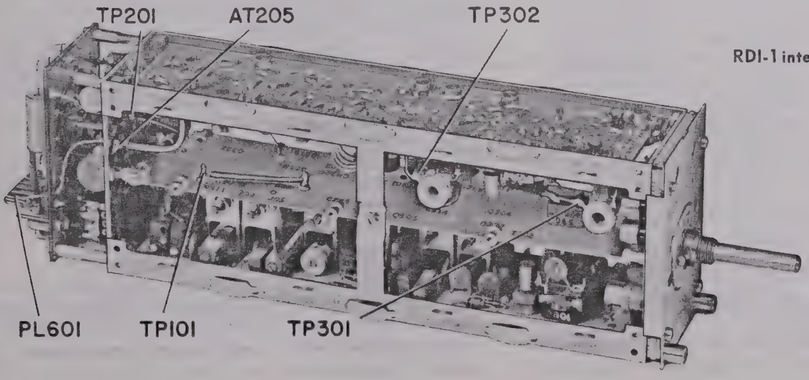


Figure DB-10.
RDI-1 interior test points and adjustments.
Unit shown inverted.

cillator frequency. If the lamp remains turned on, however, lock failure is probably due to lack of at least one of the input signals to the phase detectors. The dial-lamp sensing circuits monitor both the divider phase lock and the digit phase lock.

Depending upon which of the two phase-lock loops is suspected of malfunction, select the appropriate procedure among the two that follow.

Output-Oscillator (C138) trimmer, and Digit-Oscillator (C205) trimmers, are accessible through the top cover. It is sometimes possible to correct oscillator frequencies (as a temporary measure) by tuning the proper capacitor until lock is achieved (dial lamp will relight). Verify operation with the counter and set the trimmer to the mechanical midpoint of the capture range. Determine capture range by turning the unit on and off with the power switch, while altering the trimmer position in small steps until lock (proper frequency and lamp "on") can no longer be attained.

DB-3.3.5 MAIN-LOOP TESTS.

The main loop is comprised of the majority of the circuits in the RDI-1 and includes: the Input Mixer, the 42-Mc Buffer, the 47/47.1-Mc Buffer, the Digit Mixer, the Digit Oscillator (without its phase lock), the 50/51-Mc Buffer, the Divider Phase Detector, the Output Oscillator and Buffer, and the X5 and X2 Multipliers.

Output-Oscillator Free-Running Frequency

Depress the button under the CAD unit. Connect TP104 to TP105 with a 10-ohm resistor (use Alligator clips), to disable the phase detector. Turn the power on and observe the output-oscillator free-running frequency with the digital frequency meter connected to PL212-6, as before. The indication should be 5080 ±3 kc/s for digit settings 9 through 5, and 5030 ±3 kc/s for digit settings 4 through 0. Reset the frequency with C138, if necessary.

This test can also be performed without a digital frequency meter, if a working CAD unit and the Calibrating Mixer are used instead as a frequency meter. To do this, install the CAD unit in the chassis in the usual manner. Connect TP103 in the RDI-1 to case ground, with a short clip lead to prevent signal leakage, and use the 10-ohm resistor between TP104 and TP105, as described above.

To compare frequencies, set the front-panel MONITOR switch to CAD CAL, push the CAD substitution button under the RDI-1 to be examined, and tune the CAD for a null indication (or a slow beat) on the meter. With the CAD in the INTERNAL LOCK mode, the significant last two digits can be read directly on the CAD dial; 5030 kc/s will read as 30 on the CAD dial, etc. Remove the CAD after this test; the Calibrating Mixer can remain. Also remove the 10-ohm resistor and the ground lead at TP103.

Divider-Phase-Detector Input (Oscillator Side)

If the Output Oscillator is operative, the next step is to check the Divider-Phase-Detector input, and then work back from there.

To do this, first depress the button under the CAD unit. Since the CAD is not installed in the Main Frame, there will be no input to the RDI-1 under test (in Station VII) and, therefore, there should be no signal at TP104. Connect the VTVM (15-V scale) between case ground and TP109; a 50-Mc voltage of 3 to 4 V should be present.

If not, measure the voltage at TP107, which should be approximately 1.6 to 2.2 V at 25 Mc/s. The output oscillator amplitude measured at TP106 should be 2.5 to 2.9 V at 5 Mc/s.

Divider-Phase-Detector Input (Reference Side)

Retain the test conditions of the previous paragraph to measure the input to the Divider Phase Detector. Ground TP108 to disable the Output Oscillator. Depress the CAD OFF button, thus restoring an input signal at 5 Mc/s to the RDI-1, and measure the voltage from TP104 to ground. A signal of 2.5 to 3.5 V at 50 Mc/s should be obtained, which peaks for the middle digits and drops about equally for digits 0 and 9, when the digit-selector dial is operated.

Voltages obtained at TP103 should be 0.5 to 0.8 V, with a peak at digit 5. Connect the digital frequency meter to TP103 to measure frequency. Care should be taken not to measure the image frequency of the Digit Mixer (43.5 Mc/s instead of 50.5 Mc/s for digit 5).

The Digit-Oscillator output-signal amplitude measured at TP201 is 2.5 to 2.9 V, depending on digit setting, or approximately 1 V at TP102 (both meter leads). The second injection into the Digit Mixer is the 47+ Mc signal, 1.6 to 2.5 V, at TP101.

At TP302, 0.8 to 1.3 V of 47+ Mc/s is normally obtained; at TP301, 0.5 to 0.7 V of 42 Mc/s is present.

DB-3.3.6 DIGIT-OSCILLATOR LOOP TESTS.

The Digit-Oscillator loop includes the Digit Oscillator, the two video buffers (Q301/Q302), the Phase Detector, and Picket-Fence input transformer (T301).

Digit-Oscillator Frequency (Free-Running)

To measure the Digit-Oscillator free-running frequency, the Picket-Fence generator in the AFS has to be disabled by removal of the link between terminals 5 and 6 of L501 in the Power Supply module (component side of the etched-circuit board on top of the coil; refer to Section GA). With a properly functioning main loop, the output frequency obtained at PL212-6 for a setting of 9 is 5.0900 Mc/s (CAD OFF button depressed). Reset the RDI-1 to this frequency with C205, if necessary.

High resistance in the reed contact could raise the frequency of the 0-4 digits (K605SA or K605SB) or of a digit pair, like 3 and 8 (K601S through K604S). Operation of the reed relays may be tested at this point. The proper frequencies corresponding to the digit settings are given in Table DB-7.

Before deciding to replace reed relays, be certain to distinguish between general oscillator frequency drift, which affects all digits to approximately the same degree, and a reed failure, which shows frequency discrepancies on a pair of frequencies or the lower digits only. Since the capture range on all digits is approximately 1.5 kc/s, deviation in frequency would have to exceed this figure before a lock failure, extinguishing the dial light, would occur. With remote frequency control, it is essential to distinguish between faults inside the RDI-1 and faults in the FP-1 Filter Plug, or the remote wires and switches. If the RDI-1 Digit Oscillator produces the correct frequencies (as listed in Table DB-7) with the *manual* digit-dial settings, the digit oscillator and the reeds are operative, and the fault is outside the RDI-1 proper.

If several RDI-1's are in the chassis, substitute the FP-1 Filter Plug and remote wiring from a properly operating RDI-1, to isolate the malfunction.

TABLE DB-7

RDI-1 OUTPUT FREQUENCIES

Dial Setting	*Frequency (±0.3 Kc/s)*
9	5090.0
8	5080.0
7	5070.0
6	5060.0
5	5050.0
4	5040.0
3	5030.0
2	5020.0
1	5010.0
0	5000.0

Digit-Phase-Detector Injection (Oscillator Side)

With the Picket Fence disabled as above, measure the amplified oscillator voltage at L301 via TP303; it should be 6 to 8 V.

Digit-Phase-Detector Injection (Reference Side)

Reconnect the link on the power-supply +18 V bus (L501, 5-6) to the Picket Fence circuitry to measure the input signal at T301. Short TP201 to ground, to disable the Digit Oscillator. A peak-reading VTVM will indicate 20 – 30 V at terminals 1 or 6 of T301.

DB-3.4 DC VOLTAGE CHECKS.

The procedures of preceding paragraphs should narrow the search for circuit defects to a circuit function consisting of one or, at most, a few stages. As a further aid to pinpoint the defective part, the information on dc voltage readings is presented in Table DB-8.

DB-3.5 REPAIR AND REPLACEMENT.

Replace defective detail parts (with frequency-insensitive functions) to correct deficiencies indicated by the trouble-analysis procedures.

CAUTION

Replacement of frequency-determining parts will require realignment which cannot be accomplished without special test fixtures.

Figures DB-11 through DB-15 show the physical layout of parts on the various etched-circuit boards of the RDI-1 units, to speed positive identification. The reference designators for the parts shown on the boards are the same as those used in the over-all schematic diagram, Figure DB-16, and in the parts list at the end of this section.

If the switch portion of the reed relay becomes defective and must be replaced, proceed as follows:

a. Snip the leads at the bend, at both ends of the relay.

b. Leave the lead stub on the board, but bend it slightly at the outside end of the relay, to permit clearance for the switch portion.

c. Grasp the switch portion with a needle-nose plier, by the remaining lead end, and pull the switch out of the coil.

To install the replacement:

a. Slide the switch into the opening in the coil, align the axial leads with the lead stub from the board, so that they are touching.

CAUTION

Handle the switch lead gently to protect the glass seal.

b. Snip off the surplus lead length and solder the junction.

NOTE

The leads on K605S should not be bent nor trimmed shorter than 5/16 inch, as they are part of the over-all magnetic circuit in the relay.

TABLE DB-8

TYPICAL DC VOLTAGES

Transistor	*Emitter*	*Base*	*Collector*
Q101	1.1	0	17.8
Q102	1.1	0	17.8
Q103	1.25	1.4	17.7
Q104	16.0	15.5	0
Q105	17.8	17.5	0
Q106	3.0	0	17.7
Q107	1.75	0	17.2
Q201	16.2	15.7	0
Q301	11.5	11.2	5.1
Q302	15.0	14.5	0
Q303	17.6	17.8	0
Q304	17.6	17.8	0
Q305	0.5	0.95	17.5
Q306	0.7	1.30	17.7
Q401	4.0	4.7	11.3
Q402	11.5	11.2	8.5
Q403	1.1	0.90	0.73
Q404	1.25	1.05	1.1
Q405	1.3	1.10	1.25

PARTS LIST

RDI-1

CAPACITORS

REF NO	DESCRIPTION	PART NO
C101	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C102	Ceramic, 0.001 µF +80-20% 500V	4404-2109
C103	Mica, 22 pF ±10% 500 V	4620-0151
C104	Mica, 22 pF ±10% 500 V	4620-0151
C105	Trimmer, 7 to 25 pF 350 V	4910-2032
C106	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C107	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C108	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C109	Mica, 33 pF ±5% 500 V	4700-0301
C110	Ceramic, 1 pF ±10% 500 V	4400-0100
C111	Mica, 33 pF ±5% 500 V	4700-0301
C112	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C113	Mica, 33 pF ±5% 500 V	4700-0301
C114	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C115	Mica, 10 pF ±10% 500 V	4700-0204
C116	Mica, 10 pF ±10% 500 V	4700-0204
C117	Trimmer, 7 to 25 pF 350 V	4910-2032
C118	not used	
C119	Mica, 33 pF ±5% 500 V	4700-0301
C120	Mica, 47 pF ±5% 500 V	4700-0247
C121	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C122	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C123	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C124	Mica, 220 pF ±5% 500 V	4700-0519
C125	Mica, 27 pF ±5% 500 V	4700-0235
C126	Mica, 0.001 µF ±5% 300 V	4700-1190
C127	Ceramic, 43 pF ±5% 500 V (N750)	4417-0435
C128	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C129	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C130	Mica, 200 pF ±5% 500 V	4640-0650
C131	Mica, 12 pF ±10% 500 V	4620-0120
C132	Mica, 120 pF ±5% 500 V	4640-0520
C133	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C134	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C135	Ceramic, 8.2 pF ±5% 500 V	4400-0950
C136	Ceramic, 232 pF ±1% 500 V (N220)	4414-2321
C137	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C138	Trimmer, 2 to 8 pF 350 V	4910-2042
C201	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C202	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C203	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C204	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C205	Trimmer, 7 to 25 pF 350 V	4910-2032
C206	Mica, 91 pF ±5% 500 V	4640-0469
C207	Mica, 56 pF ±5% 500 V	4640-0321
C208	Mica, 33 pF ±10% 500 V	4620-0653
C209	Mica, 10 pF ±10% 500 V	4620-0100
C210	not used	
C211	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C212	Mica, 10 pF ±10% 500 V	4620-0100
C213	Mica, 0.001 µF ±5% 300 V	4700-1190
C214	Ceramic, 150 pF ±5% 500 V (N750)	4417-1155
C215	Mica, 0.0033 µF ±5% 300 V	4580-3300
C216	Mica, 0.00147 µF ±2% 100 V	4700-0687
C217	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C218	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C219	Ceramic, 0.02 µF +80-20% 50 V	4402-3200
C301	Mica, 0.001 µF ±10% 300 V	4700-0200
C302	Mica, 150 pF ±10% 500 V	4700-0440
C303	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C304	Ceramic, 1 µF ±20% 25 V	4400-2070
C305	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C306	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C307	Mica, 100 pF ±10% 500 V	4700-0400
C308	Mica, 100 pF ±10% 500 V	4700-0400
C309	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C310	Mica, 590pF ±2% 300 V	4700-0730
C311	Mica, 590 pF ±2% 300 V	4700-0730
C312	Ceramic, 470 pF ±10% 500 V	4404-1478
C313	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C314	Trimmer, 7 to 25 pF 350 V	4910-2032
C315	Mica, 110 pF ±5% 500 V	4640-0510
C316	Mica, 100 pF ±2% 500 V	4650-0201
C317	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C318	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C319	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C320	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C321	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C322	Mica, 68 pF ±5% 500 V	4700-0371
C323	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C324	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C401	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C402	Mica, 0.0015 µF ±10% 100 V	4700-0691
C403	Mica, 100 pF ±10% 500 V	4700-0400
C404	Ceramic, 1 µF ±20% 25 V	4400-2070
C405	Ceramic, 1 µF ±20% 25 V	4400-2070
C406	Ceramic, 1 µF ±20% 25 V	4400-2070
C407	Electrolytic, 6.8 µF ±20% 6 V	4450-4800
C408	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C409	Electrolytic, 4.7 µF ±20% 10 V	4450-4700

DIODES

REF NO	DESCRIPTION	PART NO
CR101	Type 1N995	6082-1002
CR102	Type 1N995	6082-1002
CR103	Type 1N953	6084-1006
CR201	Type 1N953	6084-1006
CR202	Type 1N953	6084-1006
CR301	Type 1N34A (S)	6082-1003
CR302	Type 1N34A (S)	6082-1003
CR401	Type 1N191	6082-1008
CR402	Type 1N191	6082-1008
CR403	Type 1N645	6082-1016
CR404	Type 1N645	6082-1016

INDUCTORS

REF NO	DESCRIPTION	PART NO
L101	Ferrite cup, adjustable	1160-2270
L102	Ferrite cup, adjustable	1160-2270
L103	Choke, iron core, 22 µH ±10%	4300-2600
L104	Choke, iron core, 22 µH ±10%	4300-2600
L105	Choke, iron core, 22 µH ±10%	4300-2600
L106	Ferrite cup, adjustable	5000-2801
L107	Ceramic, adjustable iron core	1160-2220
L108	Ceramic, adjustable iron core	1160-2450
L201	Choke, iron core, 150 µH ±10%	4300-3810
L301	Choke, iron core, 100 µH ±10%	4300-3500
L302	Choke, iron core, 1.5 µH ±10%	4300-1000
L303	Ferrite cup, adjustable	1160-2250
L304	Choke, iron core, 15 µH ±10%	4300-2400
L305	Choke, metal, 22 µH ±10%	4300-2600
L306	Coil	1160-2280

RESISTORS

REF NO	DESCRIPTION	PART NO
R101	Composition, 220Ω ±5% 1/4 W	6099-1225
R102	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R103	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R104	Composition, 47Ω ±5% 1/4 W	6099-0475

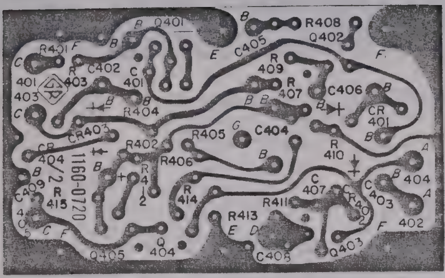

Q401
R408
Q402
R401
C402
C405
R403
C401
R409
R407
C406
CR401
R404
CR403
R405
C404
R402
R406
R410
CR404
1160-0720/2
R415
R414
C409
R413
R411
C407
CR402
C403
Q405
Q404
C408
Q403
401
403
404
402
405

Figure DB-11. Front etched-circuit board composite view (P/N 1160-2720).

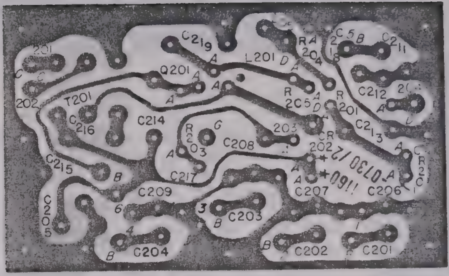

C219
L201
R204
C5
C211
Q201
201
202
T201
C216
C214
R205
R201
C212
C213
R203
C208
203
CR202
C215
C217
1160-0730/2
C209
C207
C206
C205
C203
C204
C202
C201

Figure DB-12. Inside rear etched-circuit board composite view (P/N 1160-2730).

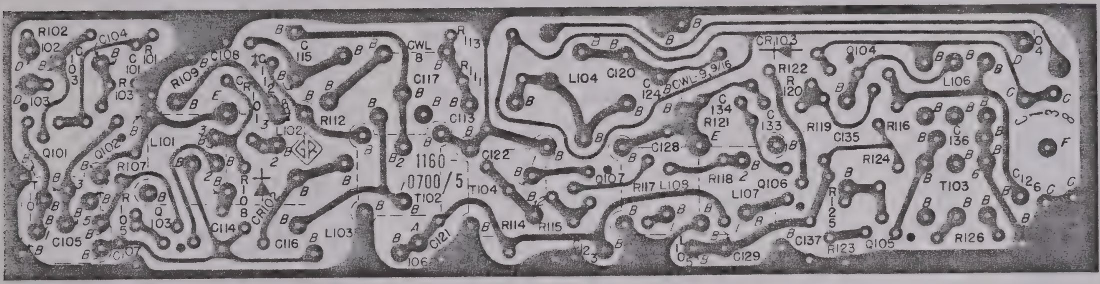

R102
C104
C101
R101
C108
C115
CWL-8
R113
CR103
Q104
R111
C117
L104
C120
C124
CWL-9 9/16
R122
R120
L106
R103
R109
CR101
C113
R112
C134
C133
R121
R119
C135
R116
C136
C138
Q101
Q102
L101
L102
1160-0700/5
C122
C128
R124
R107
R105
Q103
R108
CR102
T102
T104
Q107
R117
L108
R118
Q106
L107
R125
T103
C126
C105
C107
C114
C116
L103
C121
R114
R115
C137
R123
Q105
R126
C129
CR106
CR105

Figure DB-13. Top etched-circuit board composite view (P/N 1160-2702).

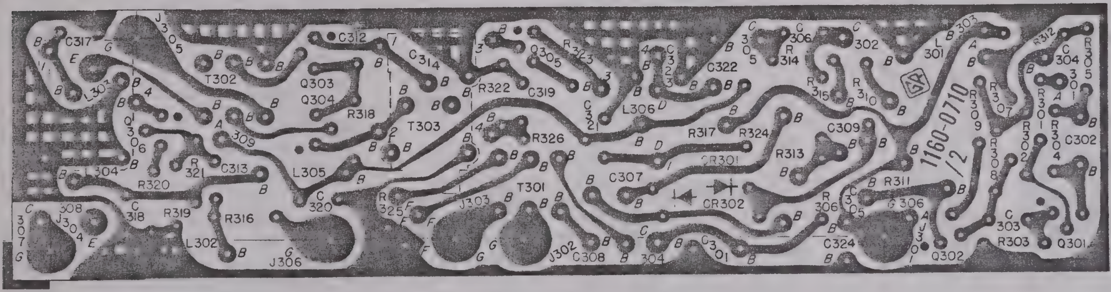

J305
C317
C312
C314
Q305
R323
C306
R314
C302
L301
R303
R312
C304
R305
L303
T302
Q303
Q304
R322
C319
C323
C322
R315
R310
R309
R307
R301
Q306
C309
R318
T303
C321
L306
R317
R324
C309
1160-0710/2
R308
R302
R304
C302
L304
R320
R321
C313
L305
R326
CR301
R313
C307
CR302
R311
CR306
R306
C305
J303
T301
C320
R325
C318
R319
R316
J304
C307
L302
J306
J302
C308
C304
C301
C324
J301
Q302
C303
R303
Q301

Figure DB-14. Bottom etched-circuit board composite view (P/N 1160-2712).

NOTE: The number on the foil side is not the part number for the complete assembly. The dot on the foil at the transistor socket indicates the collector lead.

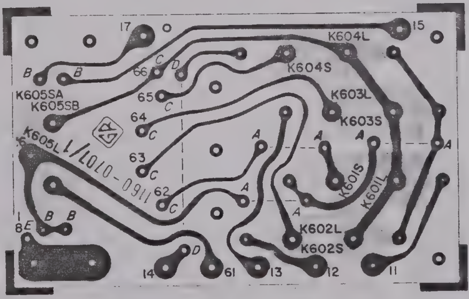
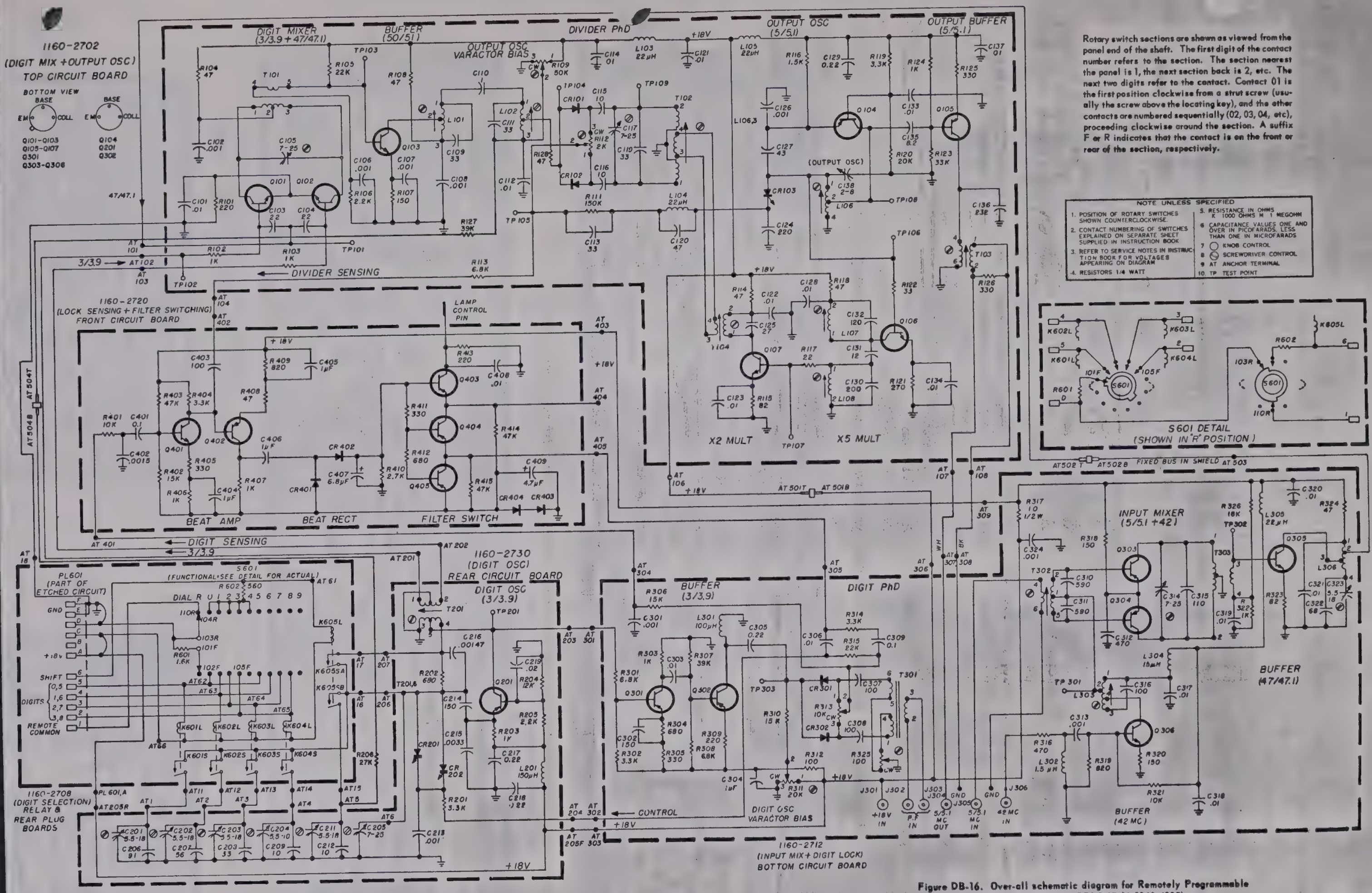

17
15
K604L
66
K604S
K605SA
K605SB
65
K603L
64
K603S
K605L
1160-0707/1
63
K601S
K601L
62
K602L
K602S
18
14
61
13
12
11

Figure DB-15. Outside rear etched-circuit board composite view (P/N 1160-2708).


1160-2702
(DIGIT MIX + OUTPUT OSC)
TOP CIRCUIT BOARD
BOTTOM VIEW
BASE
EM
COLL
Q101-Q103
Q105-Q107
Q301
Q303-Q306
Q104
Q201
Q302
DIGIT MIXER
(3/3.9 + 47/47.1)
BUFFER
(50/51)
OUTPUT OSC
VARACTOR BIAS
DIVIDER PhD
OUTPUT OSC
(5/5.1)
OUTPUT BUFFER
(5/5.1)
DIVIDER SENSING
3/3.9
47/47.1
1160-2720
(LOCK SENSING + FILTER SWITCHING)
FRONT CIRCUIT BOARD
LAMP CONTROL PIN
BEAT AMP
BEAT RECT
FILTER SWITCH
X2 MULT
X5 MULT
S601 DETAIL
(SHOWN IN 'R' POSITION)
FIXED BUS IN SHIELD
DIGIT SENSING
PL601
(PART OF ETCHED CIRCUIT)
S601
(FUNCTIONAL-SEE DETAIL FOR ACTUAL)
DIAL R U 1 2 3 4 5 6 7 8 9
GND
+18V
SHIFT
DIGITS
REMOTE COMMON
1160-2708
(DIGIT SELECTION)
RELAY & REAR PLUG BOARDS
1160-2730
(DIGIT OSC)
REAR CIRCUIT BOARD
DIGIT OSC
(3/3.9)
CONTROL
BUFFER
(3/3.9)
DIGIT PhD
DIGIT OSC
VARACTOR BIAS
1160-2712
(INPUT MIX + DIGIT LOCK)
BOTTOM CIRCUIT BOARD
INPUT MIXER
(5/5.1 + 42)
BUFFER
(47/47.1)
BUFFER
(42 MC)
+18V IN
P.F. IN
5/5.1 MC OUT
5/5.1 MC IN
42 MC IN

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS
7. ○ KNOB CONTROL
8. ⊖ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

Figure DB-16. Over-all schematic diagram for Remotely Programmable Digit Insertion Unit RDI-1 (P/N 1160-4005).

PARTS LIST (Cont)

RESISTORS (Cont)

REF NO	DESCRIPTION	PART NO
R105	Composition, 22 k ±5% 1/4 W	6099-3225
R106	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R107	Composition, 150Ω ±5% 1/4 W	6099-1155
R108	Composition, 47Ω ±5% 1/4 W	6099-0475
R109	Potentiometer, composition, 50 kΩ ±10%	6049-3508
R111	Composition, 150 kΩ ±5% 1/4 W	6099-4155
R112	Potentiometer, wire-wound, 2 kΩ ±10%	6057-2209
R113	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R114	Composition, 47Ω ±5% 1/4 W	6099-0475
R115	Composition, 82Ω ±5% 1/4 W	6099-0825
R116	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R117	Composition, 22Ω ±5% 1/4 W	6099-0225
R118	Composition, 47Ω ±5% 1/4 W	6099-0475
R119	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R120	Composition, 20 kΩ ±5% 1/4 W	6099-3205
R121	Composition, 270Ω ±5% 1/4 W	6099-1275
R122	Composition, 33Ω ±5% 1/4 W	6099-0335
R123	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R124	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R125	Composition, 330Ω ±5% 1/4 W	6099-1335
R126	Composition, 330Ω ±5% 1/4 W	6099-1335
R127	Composition, 39 kΩ ±5% 1/4 W	6099-3395
R128	Composition, 47Ω ±5% 1/4 W	6099-0475
R201	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R202	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R203	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R204	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R205	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R206	Composition, 27 kΩ ±5% 1/4 W	6099-3275
R301	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R302	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R303	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R304	Composition, 680Ω ±5% 1/4 W	6099-1685
R305	Composition, 330Ω ±5% 1/4 W	6099-1335
R306	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R307	Composition, 39 kΩ ±5% 1/4 W	6099-3395
R308	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R309	Composition, 220Ω ±5% 1/4 W	6099-1225
R310	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R311	Potentiometer, wire-wound, 20 kΩ ±10%	6057-3209
R312	Composition, 100Ω ±5% 1/4 W	6099-1105
R313	Potentiometer, wire-wound, 10 kΩ ±10%	6057-3109
R314	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R315	Composition, 22 kΩ ±5% 1/4 W	6099-3225
R316	Composition, 470Ω ±5% 1/4 W	6099-1475
R317	Composition, 10Ω ±5% 1/2 W	6100-0105
R318	Composition, 150Ω ±5% 1/4 W	6099-1155
R319	Composition, 820Ω ±5% 1/4 W	6099-1825
R320	Composition, 150Ω ±5% 1/4 W	6099-1155
R321	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R322	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R323	Composition, 82Ω ±5% 1/4 W	6099-0825
R324	Composition, 47Ω ±5% 1/4 W	6099-0475
R325	Potentiometer, composition, 100Ω ±20%	6040-0100
R326	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R401	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R402	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R403	Composition, 47 kΩ ±5% 1/4 W	6099-3475
R404	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R405	Composition, 330Ω ±5% 1/4 W	6099-1335
R406	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R407	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R408	Composition, 47Ω ±5% 1/4 W	6099-0475
R409	Composition, 820Ω ±5% 1/4 W	6099-1825
R410	Composition, 2.7 kΩ ±5% 1/4 W	6099-2275
R411	Composition, 330Ω ±5% 1/4 W	6099-1335
R412	Composition, 680Ω ±5% 1/4 W	6099-1685
R413	Composition, 220Ω ±5% 1/4 W	6099-1225
R414	Composition, 47 kΩ ±5% 1/4 W	6099-3475
R415	Composition, 47 kΩ ±5% 1/4 W	6099-3475
R601	Composition, 1.6 kΩ ±5% 1/4 W	6099-2165
R602	Composition, 560 Ω ±5% 1/4 W	6099-1565

TRANSFORMERS

REF NO	DESCRIPTION	PART NO
T101	Ceramic, adjustable iron core	1160-2230
T102	Ceramic, adjustable iron core	1160-2210
T103	Ferrite cup, adjustable	5000-2804
T104	Ceramic, adjustable iron core	1160-2200
T201	Coil assembly, adjustable	5000-2805
T301	Ferrite cup, adjustable	5000-2803
T302	Ferrite cup, adjustable	5000-2802
T303	Ceramic, adjustable iron core	1160-2240

TRANSISTORS

REF NO	DESCRIPTION	PART NO
Q101	Type 2N708	8210-3089
Q102	Type 2N708	8210-3089
Q103	Type 2N2218	8210-1028
Q104	Type 2N3638	8210-1096
Q105	Type 2N2188	8210-1045
Q106	Type 2N2218	8210-1028
Q107	Type 2N2218	8210-1028
Q201	Type 2N3638	8210-1096
Q301	Type 2N2188	8210-1045
Q302	Type 2N3638	8210-1096
Q303	Type 2N3250	8210-1089
Q304	Type 2N3250	8210-1089
Q305	Type 2N2218	8210-1028
Q306	Type 2N708	8210-3089
Q401	Type 2N696	8210-1033
Q402	Type 2N1305	8210-1305
Q403	Type 2N1303	8210-1019
Q404	Type 2N1303	8210-1019
Q405	Type 2N1303	8210-1019

MISCELLANEOUS

REF NO	DESCRIPTION	PART NO
J301 thru J306	Jack, etched-circuit, eyelet type	1160-6110
——	Knob, dial assembly	1160-1320
K601L thru K604L	Coil, relay, reed type	6090-1070
K601S thru K604S	Switch, reed relay type,SPST	6090-1060
K605L	Coil, relay, reed type	6090-1080
K605S	Switch, reed relay type,DPST	6090-1060
S601	Switch, rotary wafer, 11 pos.	7890-4160

PARTS LIST
FP-1

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C101	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C102	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C103	Ceramic, 0.1 μF +80-20 % 50 V	4401-3100
C104	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C105	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C106	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C107	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C108	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C109	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C110	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C111	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C112	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C113	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
C114	Ceramic, 0.1 μF +80-20% 50 V	4401-3100
	RESISTORS	
R102	Composition, 220 Ω ±5% 1/4 W	6099-1225
R103	Composition, 220 Ω ±5% 1/4 W	6099-1225
R104	Composition, 220 Ω ±5% 1/4 W	6099-1225
R105	Composition, 220 Ω ±5% 1/4 W	6099-1225
R106	Composition, 82 Ω ±5% 1/4 W	6099-1225
R107	Composition, 47 Ω ±5% 1/4 W	6099-1225
R108	Composition, 100 Ω ±5% 1/4 W	6099-1225
R109	Composition, 1 kΩ ±5% 1/4 W	6099-1225
R110	Composition, 1 kΩ ±5% 1/4 W	6099-1225
R111	Composition, 1 kΩ ±5% 1/4 W	6099-1225
R112	Composition, 1 kΩ ±5% 1/4 W	6099-1225
R113	Composition, 82 Ω ±5% 1/4 W	6099-1225
R114	Composition, 47 Ω ±5% 1/4 W	6099-1225
R115	Composition, 100 Ω ±5% 1/4 W	6099-1225
	MISCELLANEOUS	
L101	CHOKE, 1000 μH ±5%	4300-6383
CR101	DIODE, Semiconductor, type 1N645	6082-1016
CR102	DIODE, Semiconductor, type 1N645	6082-1016
CR103	DIODE, Semiconductor, type 1N645	6082-1016
CR104	DIODE, Semiconductor, type 1N645	6082-1016
CR105	DIODE, Semiconductor, type 1N645	6082-1016
CR106	DIODE, Semiconductor, type 1N645	6082-1016
CR107	DIODE, Semiconductor, type 1N645	6082-1016
CR108	DIODE, Semiconductor, type 1N645	6082-1016
CR109	DIODE, Semiconductor, type 1N645	6082-1016
SO101	SOCKET, Multipin	4230-5212

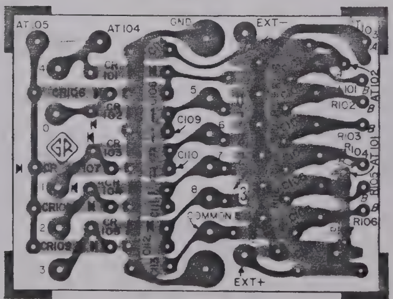


Figure DB-17. Etched-circuit board of Filter Plug unit FP-1.

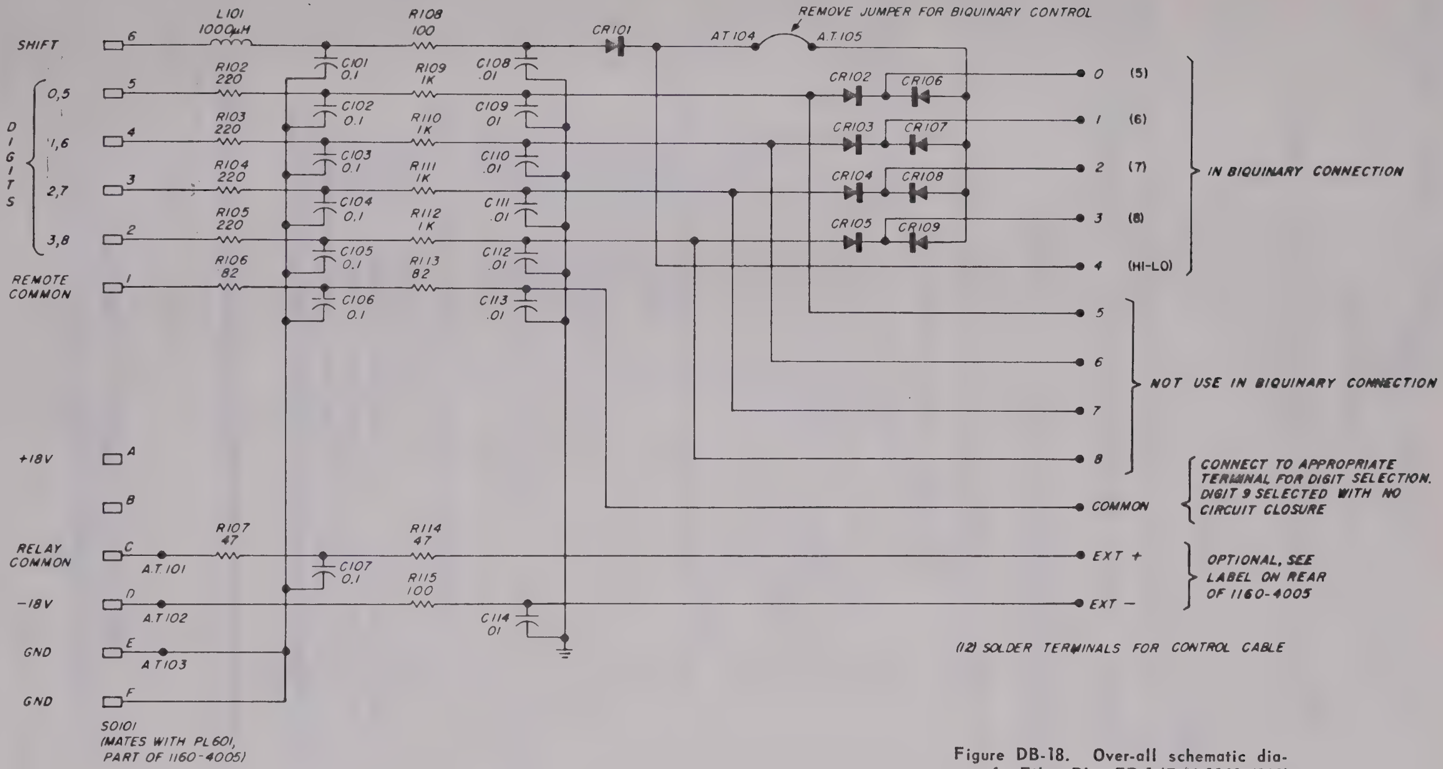

SHIFT
0,5
1,6
2,7
3,8
DIGITS
REMOTE COMMON
+18V
RELAY COMMON
-18V
GND
GND
6
5
4
3
2
1
A
B
C
D
E
F
SO101 (MATES WITH PL601, PART OF 1160-4005)
L101 1000μH
R102 220
R103 220
R104 220
R105 220
R106 82
R107 47
A.T.101
A.T.102
A.T.103
C101 0.1
C102 0.1
C103 0.1
C104 0.1
C105 0.1
C106 0.1
C107 0.1
R108 100
R109 1K
R110 1K
R111 1K
R112 1K
R113 82
R114 47
R115 100
C108 .01
C109 .01
C110 .01
C111 .01
C112 .01
C113 .01
C114 .01
CR101
AT104
A.T.105
REMOVE JUMPER FOR BIQUINARY CONTROL
CR102
CR103
CR104
CR105
CR106
CR107
CR108
CR109
0 (5)
1 (6)
2 (7)
3 (8)
4 (HI-LO)
IN BIQUINARY CONNECTION
5
6
7
8
NOT USE IN BIQUINARY CONNECTION
COMMON
CONNECT TO APPROPRIATE TERMINAL FOR DIGIT SELECTION. DIGIT 9 SELECTED WITH NO CIRCUIT CLOSURE
EXT +
EXT -
OPTIONAL, SEE LABEL ON REAR OF 1160-4005
(12) SOLDER TERMINALS FOR CONTROL CABLE

Figure DB-18. Over-all schematic diagram for Filter Plug FP-1 (P/N 1160-4090)

NOTE UNLESS SPECIFIED

1 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2 CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3 REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4 RESISTORS 1/4 WATT
5 RESISTANCE IN OHMS K - 1000 OHMS M 1 MEGOHM
6 CAPACITANCE VALUES ONE AND OVER IN PICOFARADS LESS THAN ONE IN MICROFARADS
7 ○ KNOB CONTROL
8 ⊘ SCREWDRIVER CONTROL
9 AT ANCHOR TERMINAL
10 TP. TEST POINT

CHANGE NOTICE

Service Instructions

Remotely Programmable Digit-Insertion Unit, RDI-1
Form 1160-0110-A

Paragraph DB-1.5.1 --- add at end.

> On long cable runs, the resistance of any lead should not exceed 50 ohms.

Table DB-3 --- delete and replace with the following:

TABLE DB-3

BIQUINARY CONNECTION CODE
FOR FILTER PLUG FP-1
(See Figures DB-17 and DB-18)

Solder Terminal Digit	0	1	2	3	4
9			NONE		
8				X	
7			X		
6		X			
5	X				
4					X
3				X	X
2			X		X
1		X			X
0	X				X

X = Connect terminal(s) to COM terminal to actuate digit.

Connections to solder terminals 5 through 9 not used.

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS 01781

June, 1966

Printed in U.S.A.

SERVICE INSTRUCTIONS

section DC

DIGIT - INSERTION UNIT _ DI-4

P/N 1163-4000
(Used only is the Type 1163 Synthesizers)

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Form no. 1163-0180-A ID Number B155 May 1966

GENERAL RADIO COMPANY

West Concord, Massachusetts

SECTION DC-1

INTRODUCTION

DC-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section is prepared with a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis".

Included in the following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension, by experienced service personnel, of the principles of operation. A trouble-analysis procedure that will aid in isolating the defective circuit completes the section.

To facilitate part identification, reference designators used in the text and on the photographs are the same as those that appear on the complete schemetic diagram and in the parts list. The reference designators are silk-screened on the module as a further aid in part location.

The service instructions are written to facilitate use of a properly functioning synthesizer as a basic test frame for the module. The instrument can be used to support the module, in a convenient bench-service position, and to supply it with power and test signals.

NOTE

First consideration should be given to the use of the widespread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty coverage.

DC-1.2 PURPOSE.

The DI-4 Digit-Insertion unit is employed in the General Radio Type 1163 12-Mc Coherent Decade-Frequency Synthesizer to furnish the dial-selected 1-Mc steps in the instrument output. It differs completely in function and electrical design from other Digit-Insertion units in the instrument and, although of a very similar mechanical configuration, is not interchangeable with other types of Digit-Insertion units. Mounting arrangements in the chassis are identical with those for the other digit units, comprised of two screws through the front panel to the top of the unit and a hold-down clamp at the rear. (For a description of the DI-1 module, the digit unit repetitively used for all steps in the Type 1161 and 1162 synthesizers, and for all steps but x 1 Mc/s in the Type 1163, refer to Section DA of this manual.)

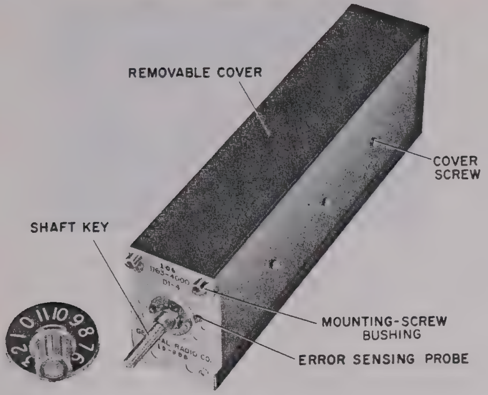


Figure DC-1.
DI-4 Digit-Insertion unit module.

DC-1.3 DESCRIPTION.

DC-1.3.1 MECHANICAL LAYOUT.

The mechanical layout of the DI-4 module is very similar to that of the DI-1 unit and consists of an assembly of four etched boards,which contains all of the electrical components that form the DI-4 circuitry.

Sheet-metal rails, on the long edges of the two larger circuit boards, run the length of the unit. Threaded inserts on these rails fasten the entire assembly. A central sheet-metal shield provides electrical isolation and additional mechanical support for the structure. Spool inserts in the edge of this shield plate serve as anchor points for the module cover.

The front of the unit consists of an etched-circuit board and structural parts. This front etched-circuit board carries the dial-lamp control circuitry. A pin on the board projects through the front of the module (see Figure DC-1) to establish electrical contact with the DI-4 dial-lamp control spring on the chassis front panel. A plate in front of this etched board carries the digit-selector switch detent mechanism. Spring contacts of finger stock around the perimeter of the front panel make a tight electrical seal with the mouth of the outer cover.

The rear of the module consists of a vertical etched board which carries the Digit Oscillator (see paragraph DC-2.3) and the rotary switch wafers operated by the front-panel control. The switch wafers and twelve tuning coils are mounted on a separate plate, on posts from the vertical etched board, that are positioned in such a way that the oscillator tuning adjustments are all accessible from the rear.

CAUTION
These are not intended for field adjustment.

The switch shaft runs the entire length of the module, just above the center shield partition.

The bottom board of the assembly carries three jacks and two ground-pickup pins, which engage contacts and banana plugs projecting from the sandwich deck.

A removable sheet-metal cover, which slides over the back of the unit, encloses the module on five sides. The cover is secured with six 4-40 screws, three per side. The cover, in addition to mechanical support and protection, provides electrical shielding for the more sensitive circuits in the module. Alignment of the unit is affected considerably by the presence or absence of this cover; consequently, the cover must be in place if the module is to function properly.

Interconnection between the etched boards is made, with two exceptions, by connection of wire links at the edges of the boards. The two exceptions are a twisted pair of wires (from top to bottom) at the front of the unit and the miniature coaxial cable, near the center, that passes through a hole in the center shield partition.

DC-1.3.2 ELECTRICAL CHARACTERISTICS.

Circuits are divided functionally at the circuit-board level, making component locations largely self-explanatory.

The DI-4 unit supplies signal outputs, frequency coherent with the master quartz oscillator in the AFS unit, necessary to produce the 1-Mc digit steps in the Type 1163 synthesizer. The function of this module in the operation of the Type 1163 system, described more fully in Section 4 of the front portion of this manual, consists of the subtraction (from the multiplied output of the DI-1 units (at 50-51 Mc/s), of frequencies in 1-Mc steps from 50 to 39 Mc/s, to obtain the 0-12-Mc output frequency. Table DC-1 gives the output frequency from the Type 1163 for each of the dial settings available.

To form the 12 frequency steps (50 to 39-Mc steps) coherently from the master crystal oscillator, the DI-4 accepts as an input, a 1-Mc sine-wave from the sandwich deck. The 1-Mc signal is generated in the AFS unit, by frequency division from the 5-Mc crystal oscillator (refer to Section CA of this manual). This 1-Mc input to the DI-4 is used as the reference to phase-lock an oscillator, which has been rough-tuned by the dial switch, to any one of the desired 50 to 39-Mc output frequencies of the DI-4. This principle is discussed more fully in Section DC-2.

The other external connections for the DI-4 consist of the +18-volt No. 1 input from the power supply and the external lamp-control pin. The lamp-control circuit is so arranged that, if the digit oscillator fails to lock, the lamp-control pin is de-energized and extinguishes the lamp in the lamp-control assembly on the front panel, to give warning of failure.

SECTION DC-2

PRINCIPLES OF OPERATION

DC-2.1 GENERAL

In this section, reference is made to the elementary schematic diagram, Figure DC-2, and the complete schematic diagram, Figure DC-14.

The principal circuit in the DI-4 is a sampled-data, automatic phase-control system which uses 1 Mc/s as a reference signal to lock a rough-tuned oscillator to a multiple of 1 Mc/s, chosen in the band of frequencies from 39 to 50 Mc/s.

The 1-Mc sine-wave input is converted to a short-duration, high-peak-power pulse with a 1-Mc repetition rate. This pulse is used to operate a gate connected to the output of the digit oscillator which, when opened by the pulse, connects the output of the oscillator to a holding capacitor that stores the instantaneous value of the oscillator output voltage when the sampling pulse occurs. If the oscillator is tuned exactly to an integer multiple of the 1-Mc input, the value of the sample is the same each time and the voltage on the holding capacitor is dc. If there is a difference between the oscillator frequency and the corresponding multiple of the 1-Mc input reference, a stepwise sinewave signal results, which represents the drift between the oscillator and the closest multiple of the 1-Mc reference. The amplified holding-capacitor voltage is used as an error signal to phase-lock the oscillator. Figure DC-3 shows the nature of this error signal.

Since an ac component of error signal is present only when the oscillator is not locked, it can be used to indicate malfunction. In the DI-4, the error

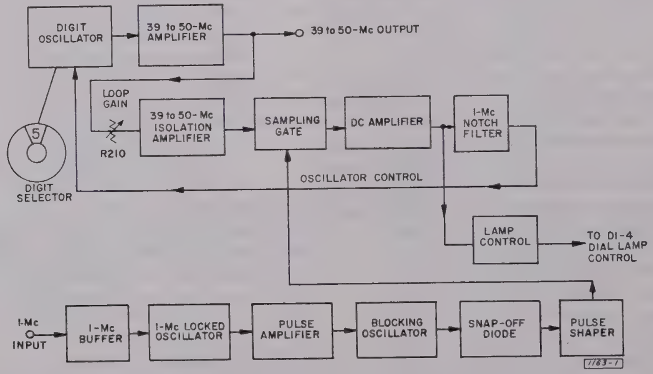

DIGIT OSCILLATOR
39 to 50-Mc AMPLIFIER
39 to 50-Mc OUTPUT
LOOP GAIN
R210
39 to 50-Mc ISOLATION AMPLIFIER
SAMPLING GATE
DC AMPLIFIER
1-Mc NOTCH FILTER
5
DIGIT SELECTOR
OSCILLATOR CONTROL
LAMP CONTROL
TO DI-4 DIAL LAMP CONTROL
1-Mc INPUT
1-Mc BUFFER
1-Mc LOCKED OSCILLATOR
PULSE AMPLIFIER
BLOCKING OSCILLATOR
SNAP-OFF DIODE
PULSE SHAPER
1183-1

Figure DC-2. DI-4 Block diagram.

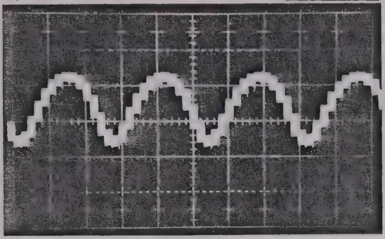


Figure DC-3. Step-wise sinewave signal at the base of Q101A indicative of the operation of the sampler circuit in response to oscillator drift.

signal is sensed for presence of ac and, if ac is found, the dial lamp is extinguished (refer to paragraph DC-2.7).

The operating principles of individual circuits are discussed in more detail below.

DC-2.2 PULSE GENERATOR.

The 1-Mc input enters the DI-4 via J203. From this point, it is fed to a tuned isolation amplifier (Q204/T204) located at the front of the unit on the bottom board. The output link on T204 connects (via AT203 and AT204) to a 1-Mc injection-locked oscillator on the front of the top board.

This oscillator is comprised of Q103/Q104 and tuned-circuit elements C111, C112 and L106. The oscillator active element is an emitter-coupled transistor pair operating as a switch. In operation the transistors are turned on alternately, with a resulting square-wave of current in each collector. The tuned-circuit filters the square-wave current in the collector of Q103, and this voltage is tapped to the Q104 base, via C113, to close the loop on the oscillator.

The injected 1-Mc signal from T204 is fed in series with the base of Q103. The collector current of Q104 drives an inductor, L107. Inductor L107 rings at its self-resonant frequency for one-half cycle; CR105 clamps the next half cycle to dissipate the remainder of the energy in the inductor.

The resulting pulse is amplified in Q105 and another self-resonant choke, L108, shortens the spike further. This spike triggers the monostable blocking oscillator Q106/T102, and the blocking oscillator cycles once for each pulse received from Q105. The amplitude of the blocking oscillator is controlled by R128. Waveforms of these various parts of the circuit can be seen in Figure DC-6.

The load for the blocking oscillator consists of R127 and a snap-off diode, CR106, at the end of a coaxial delay line, Z101. When the blocking oscillator turns on negatively, CR106 turns on also, since its anode is effectively grounded for low frequencies, through delay lines Z102 and Z104. While it is conducting, a certain amount of charge is stored in the diode junction so that, when the blocking oscillator turns off abruptly, the diode retains its high conductance (because of the mobile carriers in its junction) until the charge is swept out. Then, as the stored charge is abruptly exhausted, the diode turns off in a small fraction of a nanosecond.

This sharp transition creates a negative pulse at the anode of CR106, which propagates down Z102 until it reaches the junction of Z102, Z103, and Z104. The reflection of this pulse, from the end of shorted clipping line Z104, returns to the junction of the three delay lines with reversed phase, canceling the input. The electrical length of Z104 thus determines the width of the pulse. The pulse travels down Z103 to the sampling gate.

Delay lines Z101 to Z104 consist of the four sections of preformed, semirigid, 50-ohm coaxial cable mounted on the top board.

DC-2.3 DIGIT OSCILLATOR.

The Digit Oscillator assembly is mounted at the rear of the DI-4 module. The circuit contains one transistor, Q401, connected as a Colpitts oscillator with the base at rf ground.

Manual tuning is accomplished by switch selection of one of the 12 preset coils, L403 to L414. The

TABLE DC-1

TYPE 1163 SYNTHESIZER OUTPUT-FREQUENCY RANGES FOR DI-4 DIAL SETTINGS (Figure DC-5 and DC-14)

Synthesizer Range (Mc/s)	*DI-4 Dial Setting*	*DI-4 fout (Mc/s)*	*DI-4 Switch Position(S401)*	*Tuned by Coil*
0-1	0	50	110F 210F	L403
1-2	1	49	111F 211F	L404
2-3	2	48	112F 212F	L405
3-4	3	47	101F 201F	L406
4-5	4	46	102F 202F	L407
5-6	5	45	103F 203F	L408
6-7	6	44	104F 204F	L409
7-8	7	43	105F 205F	L410
8-9	8	42	106F 206F	L411
9-10	9	41	107F 207F	L412
10-11	10	40	108F 208F	L413
11-12	11	39	109F 209F	L414

appropriate coil is selected by S401, the only operating control on the module. The 12 coils are tuned to the frequencies shown on Table DC-1. The 2-section 12-position rotary switch and the 12 coils surrounding it are mounted on the aluminum plate at the rear of the module.

The oscillator is also voltage-tunable (at AT404) by means of a dc voltage applied to varactor diodes CR401 and CR402. These diodes are in parallel for dc, since their cathodes are tied directly together and both anodes are grounded, one directly, the other through the oscillator coil. For the rf signal, however, the diodes are in series, since the rf appears across the oscillator coil; the voltage-variable capacitance represented by the two varactors in series is also across the oscillator coil and thus across the oscillating circuit.

As the dc voltage from AT404 to ground changes, the oscillator frequency changes correspondingly due to the action of the varactors. Dc power (+18 volts) enters this assembly at AT401, and a through connection feeds this B+ to the remainder of the DI-4 circuits, via AT405.

The rf output from the Digit Oscillator is taken from T401 a 3:1 stepdown, wide-band, toroid transformer in the collector circuit of Q401. This voltage is brought out to the bottom of the oscillator-circuit assembly at AT403 and is fed to the bottom board, where it drives the two high-frequency rf amplifiers described in paragraph DC-2.4.

DC-2.4 AMPLIFIER CIRCUIT.

The bottom board contains three amplifiers, one at 1-Mc, and two at the digit-oscillator frequency. The 1-Mc input amplifier, Q204, is a common-emitter amplifier with tuned output. It is driven by 1 Mc/s entering from the sandwich deck at J203. The tuned output transformer of this stage (T204), supplies 1 Mc/s to the top etched-circuit assembly via a twisted pair of leads from a coupling link on the coil connected to AT203 and AT204.

The second amplifier, Q203, is a broadband amplifier fed by the digit oscillator at AT205, that produces the signal required at the DI-4 output (J202). It also drives the isolation amplifier, Q202 and Q201, which feeds the phase-locking servo system.

The 39-to-50-Mc output leaves the DI-4 via J202 and a ground pin. A spring on the chassis picks up this ground pin when the DI-4 is inserted in its chassis. The Q203 amplifier is a common-base stage with 2:1 stepdown transformer output. The transformer is in transmission-line form, wound on a toroid to achieve broadband characteristics. The input and output impedance of the circuit are similar, and the amplifier has 6 dB of power gain. An adjustable input attenuator, R218, controls the drive to this stage and thereby the output signal level at J202.

The third amplifier on the bottom board consists of two stages, similar to the one described in the preceding paragraph, comprised of Q202 and Q201 and their associated transformers, T202 and T201. An attenuator pad with one adjustable arm regulates the drive to this two-stage amplifier from the output of the Q203 amplifier. The purposes of this two-stage amplifier are to provide the drive signal to the sampler as part of the oscillator locking system, and to keep spurious frequency components, due to imbalances in the sampler, from appearing at the output jack. The ratio of forward-to-reverse gain of this stage is about 70 dB.

The output level of this amplifier determines the output level of the sampler; thus, adjustment of the drive to this stage from R210 controls the loop gain of the phase-lock servo system.

DC-2.5 SAMPLER AND DC AMPLIFIER SYSTEM.

DC-2.5.1 GENERAL.

The top board of the DI-4 contains the balance of the circuitry in the servo loop, including the pulse generator described in paragraph DC-2.2. The remainder of the circuits in the system include the sampler and dc control amplifier, described in the following paragraphs.

DC-2.5.2 SAMPLER.

The sampler is a normally closed gate circuit. This gate is "opened" on command from the 1-Mc repetition-rate pulse from the pulse generator described in paragraph DC-2.2. The gate remains open only for the duration of the pulse, 1 nanosecond. When the gate is open, the impedance between AT107 and the top of C105 is very low; otherwise it is very high.

The gating function is performed by the two high-speed sampling diodes, CR101 and CR102. The circuit is arranged so that the diodes are normally back biased by the voltage divider, R101, R102 and R103. A sampling pulse advancing down Z103 is converted by T103 to balanced drive for the sampler. The current in this pulse turns the diodes on through C101 and C102. The self-inductance of T101 prevents the transformer from short circuiting this very short-duration pulse. The digit-oscillator signal, however, fed in parallel to the windings of T101, appears directly on capacitors C101 and C102. Thus, when CR101 and CR102 conduct, the path through these diodes in parallel is the primary circuit between AT101 (the feedpoint for the rf) and C105, the sample-hold capacitor. C105 therefore charges very rapidly to the instantaneous rf level.

When the gate is closed, holding capacitor C105 is thus left with a charge proportional to the instantaneous level of the rf at AT101, at the time the last sample was taken. C105, when the gate is closed, is loaded only by a very high impedance determined by the Q101 bias current and the reverse leakage current through the diodes; it therefore discharges very slowly. The dc component of current in these two discharging loads is cancelled by a current fed to this point of the circuit by R104, a 10-ohm resistor. This current is determined by the setting of R105, which is adjusted so that the value of the sample charge in C105 (and the voltage across C105) is retained with minimum change, until replaced by the next sample, 1 μs later.

DC-2.5.3 DC AMPLIFIERS.

The dc amplifier in the servo loop consists of Q101, a differential-amplifier transistor pair in a single case, and Q102. The over-all voltage gain with feedback is about 3 and is designed for zero offset and minimum drift. This amplifier provides a low source impedance for the low-pass filter in the oscillator-control circuit, minimum loading on C105, and additional loop gain.

A 1-Mc notch filter (consisting of L104, C107 and L105, C108) is in series with the control line of the oscillator, so that any 1-Mc component appearing at the output of the dc amplifier does not appear at the digit-oscillator control input. Such a signal, if present, would create 1-Mc fm sidebands on the output of the DI-4.

DC-2.6 RECAPITULATION – OSCILLATOR CONTROL LOOP.

In the preceding paragraphs, the individual parts of the oscillator locking system have been described. These elements make up the oscillator locking scheme, to maintain the selected frequency outputs of the DI-4 at strict multiples of the incoming 1-Mc signal.

In review, the rf output of the digit oscillator is sampled at a 1-Mc rate controlled by the 1-Mc input. If the frequency of the digit oscillator is exactly 50 times the input signal (1-Mc), exactly 50 cycles of the 50 Mc/s will occur between samples and the value of the sample will be exactly the same each time. Its value will depend on the phase and amplitude of the 50-Mc signal. Likewise, if the rf is exactly 49 Mc/s, 49 cycles will occur between samples and the value at the instant each sampling pulse occurs will again be the same as at the previous one. The output of the sampler, since the sample is "held" by C105, will therefore be dc, if the frequency is any exact multiple of the 1-Mc sampling rate. Thus, the sampling system can make no distinction as to which multiple is being observed, only that it is, in fact, a multiple of the sampling rate.

If however the rf is not exactly a multiple of the 1-Mc input, each sample will see a different phase of the rf than it saw previously and the result will be a stepwise sinewave with a frequency equal to the amount the rf differs from the closest multiple of 1 Mc/s. This statement holds regardless of which multiple is being dealt with (see Figure DC-3).

The output of the dc amplifier is connected to the digit-oscillator varactors, CR401 and CR402, (via AT108) and corrects the digit-oscillator frequency as required to establish the integral relationship of this frequency to 1 Mc/s, at a multiple as chosen by the position of switch S401.

DC-2.7 LAMP-CONTROL CIRCUIT.

This circuit is mounted on the front etched-circuit board of the DI-4 and functions to extinguish the pilot light in front of the DI-4, if the reference signal is present but the oscillator fails to lock. This function is accomplished by sensing for the presence of ac on the oscillator control line. If ac is present, this implies that either the oscillator is not locked or the phase-lock loop is self-oscillating, either condition being a malfunction. Ac amplifier Q301 will amplify any ac present on the oscillator control line. If any ac is present, it is detected by CR301 and CR302. This changes the bias on Q302, driving Q302 out of conduction. If this occurs, the voltage on the lamp-control pin drops to zero and the lamp-control transistor on the chassis lamp-panel assembly cuts off and extinguishes the lamp. (See Sections BA and BB on the chassis for discussion of the operation of these circuits.)

SECTION DC-3

SERVICE AND MAINTENANCE

DC-3.1 INTRODUCTION.

If the system fault-localization procedure of Section 5 of the front portion of the manual indicates possible malfunction of the DI-4 unit, the most positive verification of this suspicion is the substitution of another DI-4 unit.

NOTE

DI-1 and RDI-1 units may not be substituted for a DI-4

If this step restores the instrument to normal operation,the defective DI-4 should, if possible, be returned to the General Radio Company for service and repair, especially if it is within the two-year warranty.

Since there is but one DI-4 unit per Type 1163 synthesizer, and since service spares may not be available, it will not always be possible to make the substitution as outlined above. Where this is not possible, selected tests and a few alignment steps may be made in the field. The synthesizer cannot operate without a properly functioning DI-4 module.

CAUTION

Most alignment procedures require the use of special test fixtures and cannot be accomplished in the field.

A thorough knowledge of the principles of operation, and all of the circuit arrangements by which the desired operation is achieved, is essential before DI-4 module service is attempted.

DC-3.2 TEST EQUIPMENT.

Recommended test equipment is listed and described in Table DC-2; equivalent equipment may be substituted.

TABLE DC-2

TEST EQUIPMENT

Function	*Type Recommended*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806 with 1806-P1 probe	2% accuracy; ac and dc capabilities
Dual-Trace Oscilloscope	Tektronix 543 (with C/A plug-in and P6006 10x passive probe)	20 Mc/s, 0.5 V/cm with 8 pF (or less) probe capacitance
Alignment Tool	JFD No. 5284	Insulated soft-tip screwdriver
Sampling Oscilloscope	Tektronix 661 with 4S1 and 5T1A plug-in and P6032 CF probe	1000 Mc/s; high-impedance probe
Digital Counter	GR 1144	Up to 50 Mc/s with 5-place readout
Standard Sweep Frequency Generator	GR 1025	Calibration accuracy – 0.5%

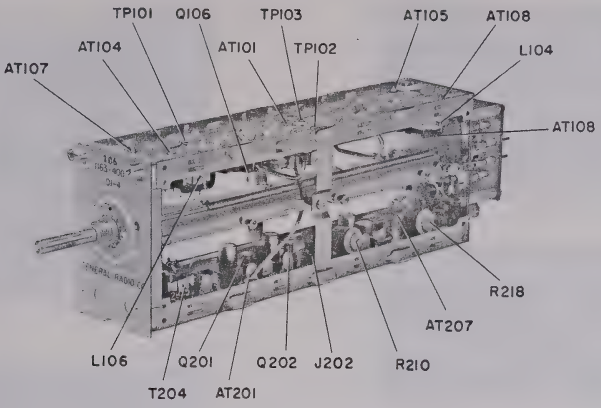

TP101
Q106
TP103
AT105
AT108
AT104
AT101
TP102
L104
AT107
AT108
R218
AT207
L106
Q201
Q202
J202
R210
T204
AT201

Figure DC-4. Interior of DI-4 module showing test points and secondary adjustment controls.

DC-3.3 TROUBLE ANALYSIS.

CAUTION

Turn power off during set-up changes to avoid accidental short circuits, which can blow F503 in the power-supply module, PS-1, (Section GA).

DC-3.3.1 GENERAL.

Remove the instrument from the cabinet, remove the DI-4 unit and the DI-1 unit in station II. For procedural details refer to Section 5.4.2 (in the front portion of the manual). Release the 6 screws in the sides and slide the cover off the DI-4. Reinstall the unit (less cover) in the chassis and install the spare DI-1 Bridging Unit (supplied) in station II.

Set the DI-4 digit dial to 5, set the DI-1 dials in any position and apply power to the synthesizer.

Refer to Figures DC-4 and DC-5 for the locations of test points and secondary adjustments referred to in procedures that follow. See also Figure DC-14, the over-all schematic diagram.

The most common symptoms of failure within the DI-4 will be the generation of improper frequencies or the failure to give any output whatever. Procedures that follow will give assurance that the difficulty is in the DI-4 module and not in some other unit and will facilitate fault isolation to the detail-part level.

DC-3.3.2 POWER INPUT.

With the VTVM, look for +18 ±0.2 Vdc at AT105 on the top circuit board. If the indication is abnormal, look at AT207 at the bottom circuit board of the DI-4. A level of approximately +17.5 Vdc should be found there and also at the collectors (cases) of Q201, Q202

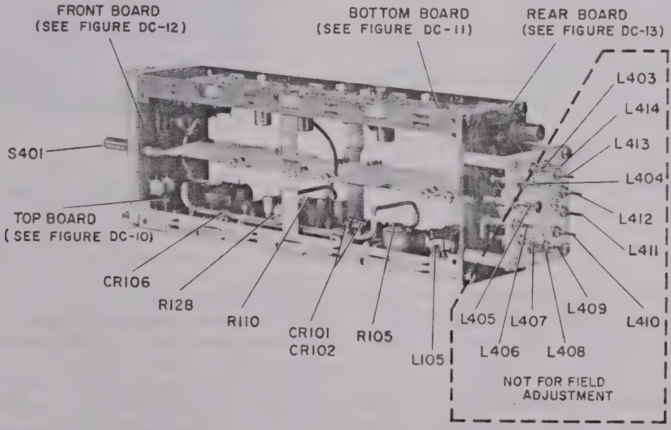

FRONT BOARD
(SEE FIGURE DC-12)
BOTTOM BOARD
(SEE FIGURE DC-11)
REAR BOARD
(SEE FIGURE DC-13)
L403
L414
L413
L404
S401
TOP BOARD
(SEE FIGURE DC-10)
L412
L411
CR106
R128
R110
CR101
CR102
R105
L105
L405
L407
L406
L409
L408
L410
NOT FOR FIELD ADJUSTMENT

Figure DC-5. Interior of DI-4 module showing test points and secondary adjustment controls (unit inverted). Refer also to Table DC-1. DO NOT CHANGE SETTING OF L403-L414.

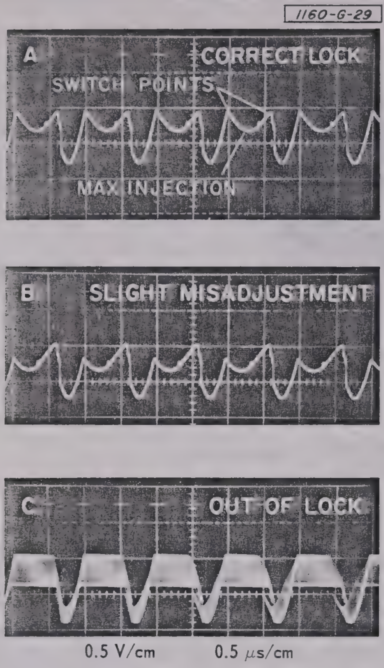


Figure DC-6. Injection-Locked Oscillator adjustment waveforms shown at TP101 (see Figure DC-4).

and Q203 on the bottom board. If the voltage is correct at AT207, but is incorrect elsewhere, the malfunction is in the DI-4. If AT207 indicates an incorrect voltage, check the power supply and chassis-power distribution in the sandwich deck (refer to Sections BB and GA).

DC-3.3.3 1-MC CIRCUITS.

With the oscilloscope, look for the 1-Mc input from the AFS module at J203. If the input signal is missing, distorted, or less than 0.7 V, rms, check the Main Frame (Section BB) and the AFS (Section CA). This test is independent of the settings of the synthesizer front panel controls.

If the 1-Mc input is adequate, observe the waveform at TP101 to check the 1-Mc isolation amplifier, Q204, and the 1-Mc Injection-Locked Oscillator, Q103/Q104. If a full sinewave appears, the oscillator is inoperative; if a half-wave-rectified sinewave appears, the isolation amplifier is not feeding a lock signal to the oscillator.

If necessary, adjust L106 to make the switching points equal in amplitude. Adjust T204 to maximize the injected signal to Q103 and Q104, as in Figure DC-6 (A). Figures DC-6 (B) and (C) show the oscillator out of adjustment.

If the oscillator cannot be brought into lock with L106, measure the frequency of the injection-locked oscillator directly, with the counter at TP101; clip a short lead across AT103 and AT104 (Figure DC-10), to remove the 1-Mc drive to the oscillator for this test.

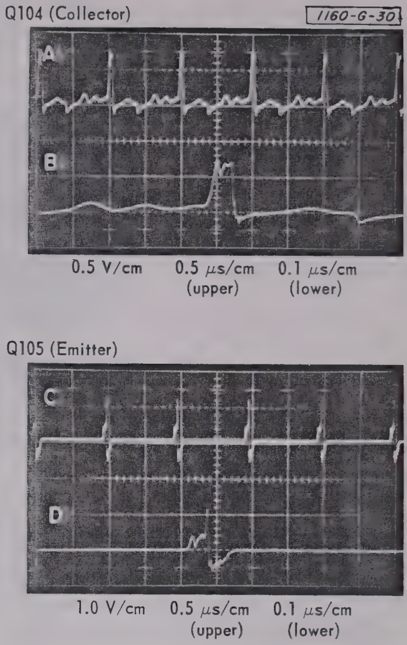


Figure DC-7. Typical input and output waveforms for the servo-circuit pulse amplifier (see Figure DC-10).

If the frequency is sufficiently removed from its nominal value, the oscillator will not lock.

DC-3.3.4 PULSE CIRCUITS.

The simplest approach to isolate trouble in stages Q103-Q106 is to signal-trace the various waveforms until a defective circuit is located. Figures DC-7 (A and B) show the waveform at the collector of Q104, the input to the pulse amplifier; the output at the emitter of Q105 is shown at Figure DC-7 (C and D).

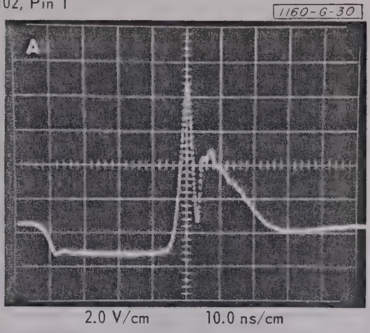
R128 controls the amplitude of the blocking-oscillator pulse, the waveform of which can be observed at the collector of Q106 (case).

CAUTION

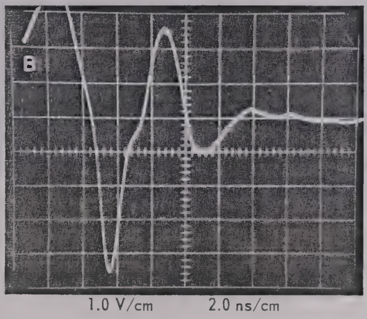
Do not change the setting of R128 unless there is a strong reason to do so, since a change in pulse amplitude can upset the sampler balance.

The sampling oscilloscope is needed for the remainder of the pulse circuits. Figure DC-8 (A) shows the output of the blocking oscillator at pin 1, T102, (use Figure DC-10 to find the test point). Figure DC-8 (B) shows the waveform at the anode of CR106. CR106, a plug-in unit, is selected to give the stored-charge, snap-off characteristics necessary to speed up the blocking-oscillator pulse. Ordinarily this diode should not need to be replaced — the jacks are utilized principally for factory selection of the diodes.

T102, Pin 1



CR106 Anode



TP103 (upper) TP102 (lower)

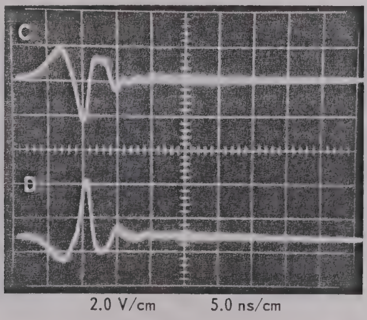


Figure DC-8. **Sampling oscilloscope waveforms typical of servo-circuit blocking-oscillator performance.**

The waveforms of the remainder of the pulse circuits are checked best when the Digit Oscillator is not running. To stop the oscillator, set the digit dial between steps. Observe the waveforms at TP102 and TP103; see Figure DC-8 (C and D). Diodes CR101 and CR102 must be removed for this test. They are plug-in units in the top circuit board (Figure DC-5). Note carefully the relative positions and polarizations of the diodes on the board prior to removal, so that they can be reinstalled exactly as they were originally.

Switch the digit selector back to one of the dial positions to restore operation of the Digit Oscillator. Reinstall the diodes.

CAUTION

Error in reinstallation of these diodes can adversely affect calibration of the entire module.

DC-3.3.5 RF CIRCUITS.

A rough estimate of the performance of the 39 to 50-Mc sections of the DI-4 module can be made by signal tracing with the oscilloscope and VTVM (see Figure DC-4).

A frequency equal to the digit-output frequency should be found progressively at the following points: AT205 at approximately 0.8 V, rms; J202 (rf Output) 0.3 V, rms (adjustable by R218); and AT201 and AT101 at about 50 - 100 mV, rms, depending on the factory setting of servo control loop-gain, (see Figure DC-11 for test points).

If gain control R210 or other elements in the servo loop become faulty, or misadjusted, the servo-control circuit may oscillate and inhibit normal phase-lock operation. Figure DC-9 is indicative of this symptom, as seen at AT107. This condition cannot be adjusted in the field.

CAUTION

Do not change the setting of R210.

DC-3.3.6 DC AMPLIFIER.

Table DC-3 includes the voltages that should be obtained in the dc amplifier circuits.

DC-3.3.7 NOTCH FILTER.

Remove Q106 to stop the pulse generator. Connect the VTVM (DC mode) to AT108 and adjust R105 to a 6.0 Vdc indication; a right-angle screwdriver can be used for this adjustment.

Connect two 33 kilohm resistors to the base of Q101A, one going to TP101 and the other to TP102,

TABLE DC-3

DC VOLTAGE INDICATIONS

Transistor	*Emitter*	*Base*	*Collector*
Q101A	5.5	6	14.5
Q101B	5.5	6	17.5
Q102	15	14.5	6
Q103	9.2	9.0	0.3
Q104	9.2	9.1	0+
Q105	0+	0+	16.8
Q106	0	-.52	5.5
Q201	11.2	11.9	16.5
Q202	11.5	12.1	17.0
Q203	4.3	5.0	16
Q204	10	10.1	0
Q301	5.5	6.0	11
Q302	.063	.045	.058
Q401	11.5	12.2	17

(across the diodes), to maintain the bias on Q101A. Connect the signal generator, to the base of Q101A, through a 0.01-μF coupling capacitor. Sweep through 1 Mc/s at 0.1 V, rms, and with the VTVM (ac mode), observe the voltage at AT108. The ac voltage output of the amplifier should go through a minimum at 1 Mc/s. If the notch can't be found, the unit must be returned to General Radio for realignment.

DC-3.4 DC VOLTAGE CHECKS.

The procedures in paragraph 3.3 should narrow the search for circuit defects to a circuit function consisting of one, or at the most, a few stages. As a further aid to pinpointing the defective part, the information on dc voltage readings is presented in Table DC-3.

DC-3.5 REPAIRS AND REPLACEMENT.

Replace defective detail parts (with frequency-insensitive functions) to correct deficiencies indicated by the trouble-analysis procedures.

CAUTION

Replacement of frequency-determining parts will require realignment which cannot be accomplished without special test fixtures.

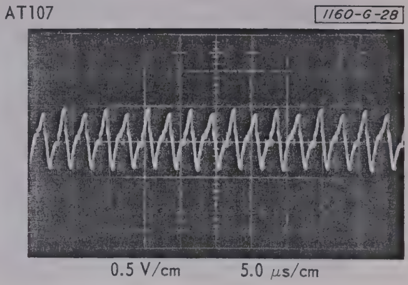


Figure DC-9. Typical waveform at AT107 indicating self-oscillation resulting from an incorrect setting of R210, the Digit Oscillator control-loop gain control.

Figures DC-10 through DC-13 show the physical layout of the parts on the various etched-circuit boards, to speed positive identification. The reference designators for the parts shown on the boards are the same as those used in the over-all schematic diagram, Figure DC-14, and in the parts list at the end of this section.

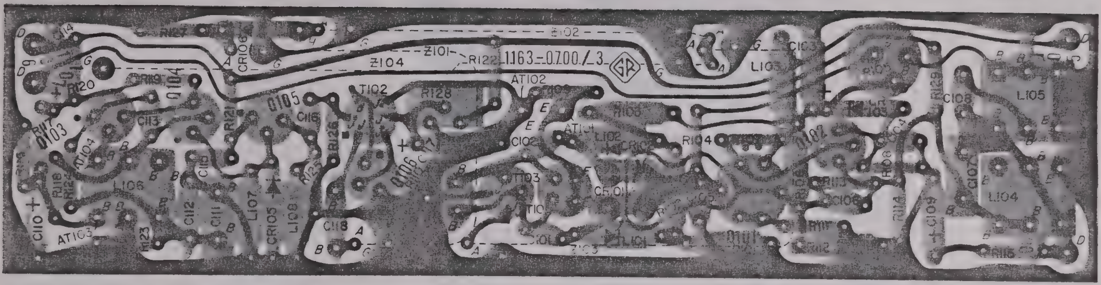

1163-0700/3
Z102
Z101
Z104
R122
C114
R127
CR106
C103
L103
L105
C108
R129
Q104
Q105
Q103
R120
R119
R121
C116
C113
R126
T102
R128
AT102
AT101
L102
R106
R104
Q102
C102
T103
C501
L106
L107
L108
CR105
C112
C111
C115
C118
C110
AT103
R123
R118
C107
L104
C109
R114
R116
Q101
LI01
C106
R113
R108
R111

Figure DC-10. Etched-circuit board assembly (top) for DI-4 (P/N 1163-2701).

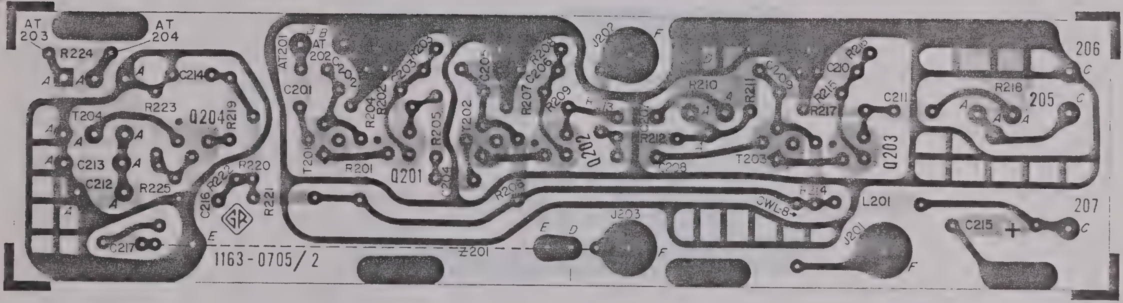

AT
203
AT
204
R224
C214
T204
R223
Q204
R219
C213
C212
R225
R220
R222
C216
R221
C217
1163-0705/2
AT201
AT
202
C202
C201
R204
R202
R203
R205
T201
R201
Q201
C204
T202
C205
R207
C206
R208
R209
R206
J202
Q202
R213
R212
C208
R210
R211
C209
C210
R216
R215
R217
T203
Q203
C211
R218
205
206
207
L201
R214
CWL-8
J203
Z201
J201
C215

Figure DC-11. Etched-circuit board assembly (bottom) for DI-4 (P/N 1163-2706).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

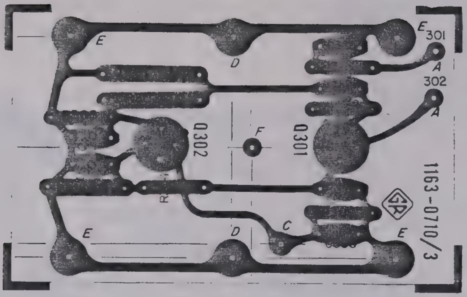

E
D
E
301
A
302
A
Q302
F
Q301
1163-0710/3
E
D
C
E

Figure DC-12. Etched-circuit board assembly (front) for DI-4 (P/N 1163-2710).

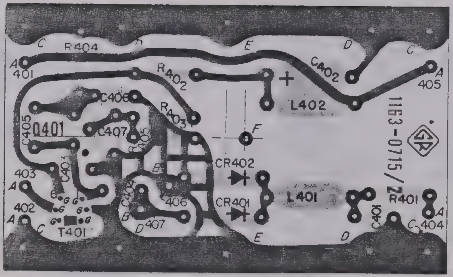

C
R404
D
E
D
C
A
401
R402
C402
A
405
+
C406
R403
L402
Q401
C405
C407
F
1163-0715/2
403
A
C403
CR402
CR401
L401
R401
402
A
406
407
T401
E
D
C401
A
404
C

Figure DC-13. Etched-circuit board assembly (rear) for DI-4 (P/N 1163-2716).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

PARTS LIST

CAPACITORS

REF NO	DESCRIPTION	PART NO
C101	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C102	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C103	Electrolytic, 2.2 μF ±20% 20 V	4450-4500
C104	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C105	Ceramic, 10 pF ±5% 500 V (NPO)	4410-0105
C106	Ceramic, 27 pF ±5% 500 V (N750)	4417-0275
C107	Mica, 243 pF ±1% 500 V	4710-0424
C108	Ceramic, 20 pF ±5% 500 V (N150)	4413-0205
C109	Electrolytic, 2.2 μF ±20% 20 V	4450-4500
C110	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C111	Mica, 508 pF ±1% 500 V	4710-0579
C112	Ceramic, 91 pF ±5% 300 V (N750)	4417-0915
C113	Ceramic, 10 pF ±5% 500 V (NPO)	4410-0105
C114	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C115	Ceramic, 0.0047 μF +80-20% 500 V	4450-4300
C116	Ceramic, 470 pF ±10% 500 V	4405-1478
C117	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C118	Ceramic, 0.02 μF +80-20% 50 V	4402-3200
C201	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C202	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C203	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C204	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C205	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C206	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C207	Ceramic, 0.01 μF ±10% 500 V	4405-2108
C208	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C209	Ceramic, 0.01 +80-20% 50 V	4401-3100
C210	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C211	Ceramic, 0.01 μF ±10% 500 V	4405-2108
C212	Mica, 508 pF ±1%	4710-0579
C213	Ceramic, 91 pF ±5% (N750)	4417-0915
C214	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C215	Electrolytic, 2.2 μF ±20% 20 V	4450-4500
C216	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C217	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C301	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C302	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C303	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C304	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C305	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C306	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C401	Ceramic, 20 pF ±5% 500 V (N750)	4417-0205
C402	Electrolytic, 1.0 μF ±20% 35 V	4450-4300
C403	Ceramic, 0.0022 μF +80-20% 500 V	4404-2229
C404	Ceramic, 24 pF ±5% 500 V (N750)	4417-0245
C405	Ceramic, 24 pF ±5% 500 V (N750)	4417-0245
C406	Ceramic, 180 pF ±5% 500 V	4404-1185
C407	Ceramic, 0.0022 μF +80-20% 500 V	4404-2229

DIODES

REF NO	DESCRIPTION	PART NO
CR101	Semiconductor,	6082-1019
CR102	Semiconductor,	6082-1019
CR103	Semiconductor, type 1N746	6083-1005
CR105	Semiconductor, type 1N191	6082-1008
CR106	Semiconductor, type 1N3604	6082-1001
CR301	Semiconductor, type 1N191	6082-1008
CR302	Semiconductor, type 1N191	6082-1008
CR303	Semiconductor, type TI-56	6082-1016
CR401	Semiconductor, type VA-134	6084-1010
CR402	Semiconductor, type VA-134	6084-1010

INDUCTORS

REF NO	DESCRIPTION	PART NO
L101	Choke, iron core 1.5 μH ±10%	4300-1000
L102	Choke, iron core 1.5 μH ±10%	4300-1000
L103	Choke, iron core 22 μH ±10%	4300-2600
L104	Ferrite cup, adjustable	5000-2832
L105	Ferrite cup, adjustable	5000-2833
L106	Ferrite cup, adjustable	5000-2834
L107	Choke, iron core 22 μH ±10%	4300-2600
L108	Choke, iron core 1.5 μH ±10%	4300-1000
L201	Choke, iron core 22 μH ±10%	4300-2600
L401	Choke, iron core 4.7 μH ±10%	4300-1600
L402	Choke, iron core 22 μH ±10%	4300-2600
L403	Ceramic, iron core, adjustable	1163-2200
L404	Ceramic, iron core, adjustable	1163-2200
L405	Ceramic, iron core, adjustable	1163-2200
L406	Ceramic, iron core, adjustable	1163-2200
L407	Ceramic, iron core, adjustable	1163-2210
L408	Ceramic, iron core, adjustable	1163-2210
L409	Ceramic, iron core, adjustable	1163-2210
L410	Ceramic, iron core, adjustable	1163-2210
L411	Ceramic, iron core, adjustable	1163-2220
L412	Ceramic, iron core, adjustable	1163-2220
L413	Ceramic, iron core, adjustable	1163-2220
L414	Ceramic, iron core, adjustable	1163-2220

RESISTORS

REF NO	DESCRIPTION	PART NO
R101	Film, 4.99 kΩ ±1% 1/8 W	6250-1499
R102	Film, 2 kΩ ±1% 1/8 W	6250-1200
R103	Film, 11 kΩ ±1% 1/8 W	6250-2110
R104	Composition, 10 MΩ ±5% 1/4 W	6099-6105
R105	Potentiometer, composition 100 kΩ ±20%	6040-1000
R106	Film, 20 kΩ ±1% 1/8 W	6250-2200
R107	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R108	Composition, 3.9 kΩ ±5% 1/4 W	6099-2395
R109	Composition, 47 Ω ±5% 1/4 W	6099-0475
R110	Potentiometer, composition 100 Ω ±20%	6040-0100
R111	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R112	Film, 10 kΩ ±1% 1/8 W	6250-2100
R113	Composition, 22 kΩ ±5% 1/4 W	6099-3225
R114	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R115	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R116	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R117	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R118	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R119	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R120	Composition, 100 Ω ±5% 1/4 W	6099-1105
R121	Composition, 330 Ω ±5% 1/4 W	6099-1335
R122	Composition, 680 Ω ±5% 1/4 W	6099-1685
R123	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R124	Composition, 220 Ω ±5% 1/4 W	6099-1225
R125	Composition, 150 Ω ±5% 1/4 W	6099-1155
R126	Composition, 820 Ω ±5% 1/4 W	6099-1825
R127	Composition, 220 Ω ±5% 1/4 W	6099-1225
R128	Potentiometer, wire-wound 2 kΩ ±5%	6053-1105
R129	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R201	Composition, 100 Ω ±5% 1/4 W	6099-1105
R202	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R203	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R204	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R205	Composition, 22 Ω ±5% 1/4 W	6099-0225
R206	Composition, 100 Ω ±5% 1/4 W	6099-1105

PARTS LIST (Cont)

RESISTORS (Cont)

REF NO	DESCRIPTION	PART NO
R207	Composition, 6.8 kΩ ±5% 1/4 W	6099-2685
R208	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R209	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R210	Potentiometer, composition 100 Ω ±20%	6040-0100
R211	Composition, 12 Ω ±5% 1/4 W	6099-0125
R212	Composition, 100 Ω ±5% 1/4 W	6099-1105
R213	Composition, 51 Ω ±5% 1/4 W	6099-0515
R214	Composition, 100 Ω ±5% 1/4 W	6099-1105
R215	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R216	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R217	Composition, 270 Ω ±5% 1/4 W	6099-1275
R218	Potentiometer, composition 100 Ω ±20%	6040-0100
R219	Composition, 220 Ω ±5% 1/4 W	6099-1225
R220	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R221	Composition, 100 Ω ±5% 1/4 W	6099-1105
R222	Composition, 8.2 kΩ ±5% 1/4 W	6099-2825
R223	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R224	Composition, 33 Ω ±5% 1/4 W	6099-0335
R225	Composition, 470 Ω ±5% 1/4 W	6099-1475
R301	Composition, 220 Ω ±5% 1/4 W	6099-1225
R302	Composition, 820 Ω ±5% 1/4 W	6099-1825
R304	Composition, 680 Ω ±5% 1/4 W	6099-1685
R305	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R306	Composition, 330 Ω ±5% 1/4 W	6099-1335
R401	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R402	Composition, 150 Ω ±5% 1/4 W	6099-1155
R403	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R404	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R405	Composition, 150 kΩ ±5% 1/4 W	6099-4155

TRANSISTORS

REF NO	DESCRIPTION	PART NO
Q101	Type 2N2453	8210-1046
Q102	Type 2N3250	8210-1089
Q103	Type 2N3638	8210-1096
Q104	Type 2N3638	8210-1096
Q105	Type 2N708	8210-3089

TRANSISTORS (Cont)

REF NO	DESCRIPTION	PART NO
Q106	Type 2N2369	8210-1052
Q201	Type 2N708	8210-3089
Q202	Type 2N708	8210-3089
Q203	Type 2N2218	8210-1028
Q204	Type 2N3638	8210-1096
Q301	Type SE4002	8210-1077
Q302	Type 2N1305	8210-1305
Q401	Type 2N918	8210-1066

MISCELLANEOUS

REF NO	DESCRIPTION	PART NO
Z101	Delay line, rigid-wall coaxial, miniature	1163-0201
Z102	Delay line, rigid-wall coaxial, miniature	1163-0202
Z103	Delay line, rigid-wall coaxial, miniature	1163-0203
Z104	Delay line, rigid-wall coaxial, miniature	1163-0204
Z201	Delay line, rigid-wall coaxial, miniature	1163-0200
J201	JACK, etched-circuit, eyelet-type	1160-6110
J202	JACK, etched-circuit, eyelet-type	1160-6110
J203	JACK, etched-circuit, eyelet-type	1160-6110
S401	SWITCH, rotary wafer	7890-4300
T101	TRANSFORMER, video, interstage	5000-2403
T102	TRANSFORMER, video, interstage	5000-2601
T103	TRANSFORMER, video, interstage	5000-2403
T201	TRANSFORMER, video, interstage	5000-2401
T202	TRANSFORMER, video, interstage	5000-2401
T203	TRANSFORMER, video, interstage	5000-2401
T204	TRANSFORMER, ferrite cup, adjustable	5000-2835
T401	TRANSFORMER, ferrite cup, adjustable	5000-2602

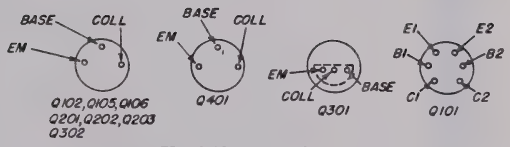
CIRCUIT BOARD – ASSEMBLIES

REF NO	DESCRIPTION	PART NO
	Top circuit board	1163-2701
	Bottom circuit board	1163-2706
	Front circuit board	1163-2710
	Rear circuit board	1163-2716

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

NOTE UNLESS SPECIFIED

1 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2 CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3 REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4 RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10 TP TEST POINT



TRANSISTORS BOTTOM VIEW

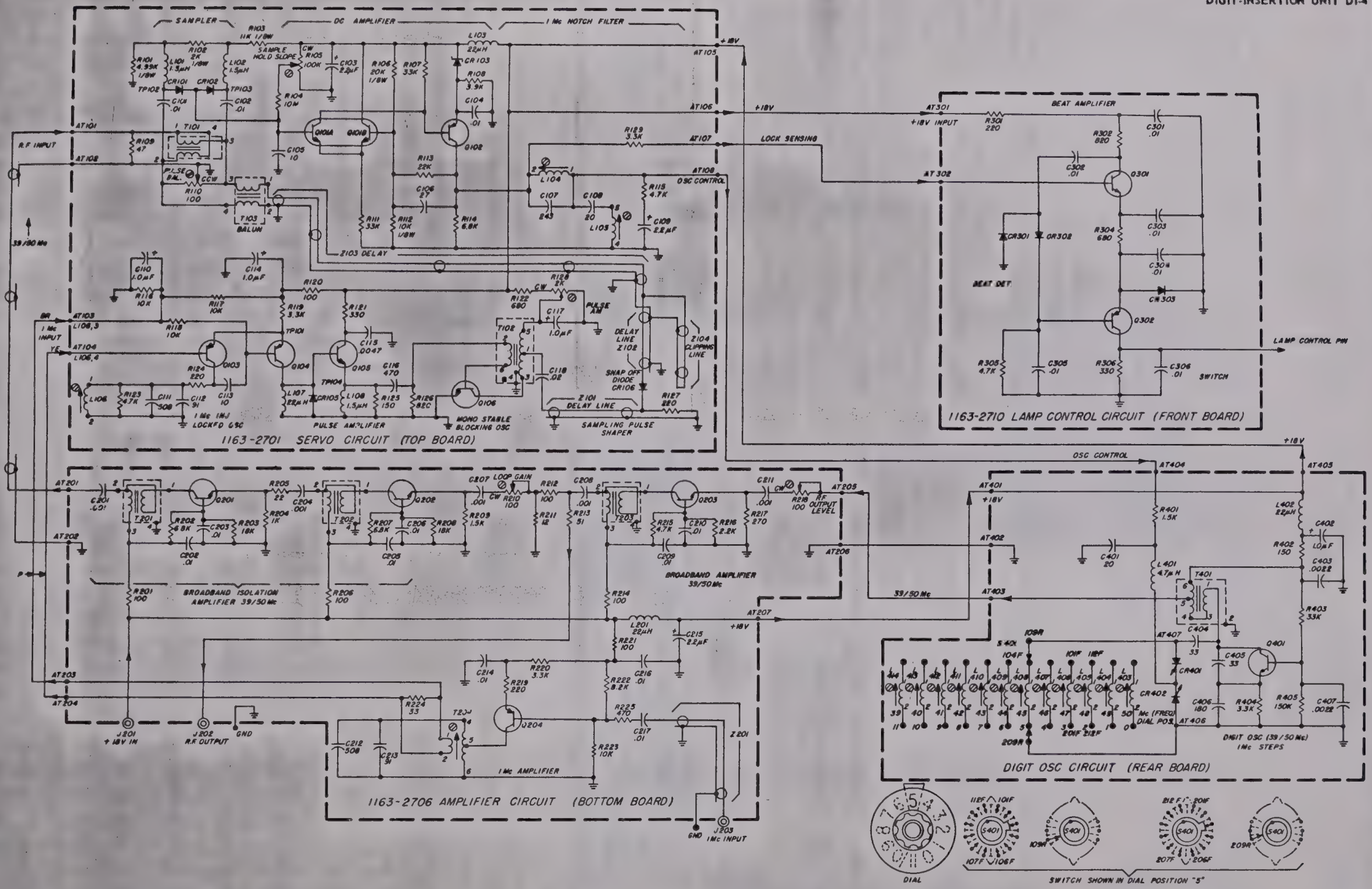

SAMPLER
DC AMPLIFIER
1 Mc NOTCH FILTER
SAMPLE HOLD SLOPE
R.F INPUT
39/50 Mc
1 Mc INPUT
BALUN
Z103 DELAY
PULSE BAL.
PULSE AMP
DELAY LINE Z102
SNAP OFF DIODE CR106
Z104 CLIPPING LINE
Z101 DELAY LINE
SAMPLING PULSE SHAPER
MONO STABLE BLOCKING OSC
PULSE AMPLIFIER
1 Mc INJ LOCKED OSC
1163-2701 SERVO CIRCUIT (TOP BOARD)
+18V
AT105
AT106
AT107
AT108
OSC CONTROL
LOCK SENSING
AT301
+18V INPUT
AT302
BEAT AMPLIFIER
BEAT DET
LAMP CONTROL PIN
SWITCH
1163-2710 LAMP CONTROL CIRCUIT (FRONT BOARD)
LOOP GAIN
RF OUTPUT LEVEL
BROADBAND ISOLATION AMPLIFIER 39/50 Mc
BROADBAND AMPLIFIER 39/50 Mc
1 Mc AMPLIFIER
J201 +18V IN
J202 R.F OUTPUT
GND
J203 1 Mc INPUT
1163-2706 AMPLIFIER CIRCUIT (BOTTOM BOARD)
33/50 Mc
AT401
AT402
AT403
AT404
AT405
AT406
AT407
1 Mc (FREQ) DIAL POS.
DIGIT OSC (39/50 Mc) 1 Mc STEPS
DIGIT OSC CIRCUIT (REAR BOARD)
DIAL
SWITCH SHOWN IN DIAL POSITION "5"

Figure DC-14. Over-all schematic diagram for the Digit-Insertion Unit DI-4 (P/N 1163-4000).

SERVICE INSTRUCTIONS

section EA

CONTINUOUSLY ADJUSTABLE DECADE – CAD-1

P/N 1160-4020

CALIBRATING MIXER – CM-1

P/N 1160-4030

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Form No. 1160-0120-A ID Number B165 March 1966

GENERAL RADIO COMPANY

West Concord, Massachusetts

SECTION EA-1

INTRODUCTION

EA-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section is prepared from a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis".

Included in the following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension by experienced service personnel of the principles of operation. A trouble-analysis procedure that will aid in isolation of defective circuits completes the section.

To facilitate part identification, reference designators used in the text and appearing on the photographs are the same as those used on the complete schematic diagram and in the parts list.

The service instructions rely on use of a properly functioning synthesizer as a basic test frame for individual modules. The instrument can be used to support the module, in a convenient bench-service position, and to supply it with power and test signals.

NOTE

First consideration should be given to the use of the widespread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty coverage.

EA-1.2 PURPOSE.

EA-1.2.1 CAD FUNCTION.

The Continuously Adjustable Decade, or CAD, like the Digit-Insertion unit, is an element used directly in the generation of a dial-selected output frequency in General Radio synthesizers.

For many applications it is desirable, even in a highly stable signal source, to have the capability to vary frequency continuously rather than in steps, however fine these may be. The CAD provides this continuous coverage. To use the CAD one simply pushes the button under the DI-1 unit where continuous control is desired. The CAD now replaces this DI-1 unit and all others to the right of it. Thus, by simple operation of appropriate pushbutton switches, the CAD can be connected so that one of its 12 major divisions covers frequency increments from 100 kc/s to .001 c/s, depending upon the size of the step-digit replaced.

In addition to manual control by the dial, the CAD frequency can be voltage-controlled. This sweep capability greatly increases the usefulness of the CAD for response plotting and similar applications.

To achieve this versatility, two operational modes, selected by a switch located on the right-hand side of the CAD dial, are available in this unit.

First an INTERNAL LOCK mode provides manual-frequency control by the dial only. In this position, the CAD has superior frequency stability and the dial is accurate to two places; the dial illumination is bright.

In the EXTERNAL CONTROL mode, in addition to the dial setting, frequency control by an external voltage on the EXTERNAL CAD CONTROL binding posts is possible. A level change of 0.3 V (with respect to ground) is required to sweep 1 major CAD division. The resulting reduction in frequency accuracy is signified by the dim dial illumination.

While the CAD produces the same frequency as a DI-1 for corresponding dial settings, its range extends a decade at both ends for greater convenience. Frequencies corresponding to digits -1 and +11 can be covered manually. A range of at least ±5 major divisions, centered around any position on the dial, is available when voltage tuned.

Two oscillators, with variable ganged capacitors and associated circuitry to perform these functions, are housed in a package dimensionally identical to the DI-1. It is also a convenient plug-in module, self-connecting upon installation. Plug layout is different from that used in the DI-1, and the unit can only be installed in its proper station at the right-hand end of the Main Frame, on top.

EA-1.2.2 CALIBRATING MIXER – CM-1.

In either one of the two modes, the CAD can be quickly calibrated against the primary crystal to at least four places (on its control dial) by means of the Calibrating Mixer. This unit is a small separate assembly mounted behind the CAD on the main deck (four-place calibration requires at least four DI-1 units in the chassis).

EA-1.3 DESCRIPTION.

EA-1.3.1 CAD MODULE.

The Continuously Adjustable Decade, with its cover and dial installed, is shown in Figure EA-1. The external mechanical controls of the unit, the shaft that operates ganged capacitors and the concentric mode-selector switch, are located on the front. The dial, aside from the major divisions corresponding to those of the DI-1 units, has minor divisions (on a panel-mounted scale) to permit direct reading to two digit places. The interpretation of the dial system, which includes the engraving on the lamp holder, is covered in paragraph 3.7 in the front portion of this manual.

The entire CAD assembly is held in the Main Frame by two 4-40 screws that engage the threaded bushings in the top corners of the small front panel, and a hold-down clamp that secures the reinforced bottom of the cover, through a small cutout in the back.

All electrical connections to the CAD are made by banana-type plugs from the Main Frame, through the bottom of the cover into the CAD assembly. The dial light is energized and switch-controlled in the Main Frame as explained in paragraph 4.6 (front portion); it is also controlled in brightness by the mode switch (EXTERNAL CONTROL – INTERNAL LOCK). To achieve this, the crank operating the mode switch contacts a small spring on the lamp-switching card behind the front panel (refer to Sections BA or BB for details).

Two 4-40 screws on either side of the unit fasten the cover to the CAD unit frame structure. After their removal, the unit may be withdrawn from the cover by holding the case in one hand and pulling the unit by the capacitor shaft with the other.

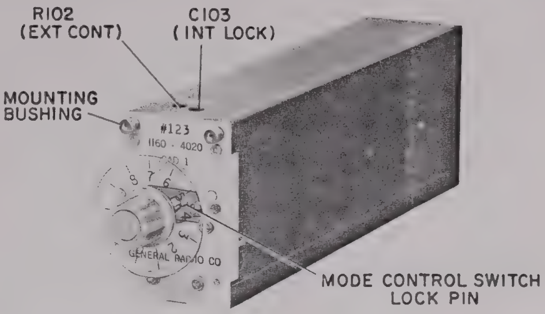


Figure EA-1.
Continuously Adjustable Decade CAD module.

The circuitry of the CAD is contained on four etched-circuit boards. They are the longer (horizontal) top and bottom boards and the smaller (vertical) front and rear circuit boards. These boards mount most of the components and provide for connections between them. The circuit boards are joined to the ganged-capacitor assembly through the side rails and the front panel, thus forming the structure of the CAD.

Four banana-plug receptacles are located in the bottom board and two in the ganged-capacitor assembly. These furnish the electrical connections.

Signal flow and circuit layout are arranged so that a minimum of wiring between boards is required. Each circuit-board assembly can be removed from the structure after connecting-wire leads are unsoldered and appropriate screws removed. There is, however, enough space in almost all instances to permit removal of components from the board directly. It is important to take special precautions to protect the capacitor plates from damage or deformation.

The side rails of the top and bottom boards are equipped with special ground springs to ensure intimate contact with the cover. The four threaded inserts, which accept the 4-40 screws holding the cover, establish fixed-contact areas between the horizontal shield partition and cover. A finger-stock rf seal secures the junction of the cover and the CAD front panel.

EA-1.3.2 CM-1 MODULE.

The Calibrating Mixer is a small separate unit that mounts behind the CAD on the upper deck. It contains a single etched board to which small side rails are joined. The etched-circuit board is equipped with an integral edge-type plug, which engages a receptacle on the chassis. The cover, which is attached to the side rails, holds the unit down by means of three 4-40 screws into the deck.

SECTION EA-2

PRINCIPLES OF OPERATION

EA-2.1 SIGNAL FLOW.

EA-2.1.1 GENERAL.

The main circuits of the CAD are shown in the block diagram, Figure EA-2. (Refer also to the schematic diagram, Figure EA-11, in which the four circuit boards are distinguished by heavy outlines.) In accordance with the flow in the synthesizer itself, where the signal is fed from DI-1 to DI-1 (or from the CAD to a DI-1), from right to left, the main signal flow in the block diagram is from right to left along the horizontal axis of the figure. This signal flow pertains to the INTERNAL LOCK mode of operation, in which all blocks shown are active (covered in detail in paragraph EA-2.1.3).

EA-2.1.2 EXTERNAL CONTROL MODE.

The CAD can "replace" any DI-1 in the 1160-series synthesizers and it must therefore produce output frequencies between 5.0 and 5.1 Mc/s. The free-runing Output Oscillator is tuned through this band by one section of a ganged capacitor; in addition, a varactor diode is employed in the tank circuit. The narrow frequency range makes a nearly linear voltage control possible. A control voltage of 0.3 V applied to the varactor changes frequency 10 kc/s or one major division on the dial (one step on a DI-1). Coupling of this voltage from the EXTERNAL CAD CONTROL binding posts is dc, so that angle modulation, frequency shift, or phase locking is possible. The center frequency is still controlled by the dial-driven variable capacitor.

In this mode, the output oscillator and the output buffer on the left in the block diagram are the only active components. Frequency coverage is 4.99 to 5.11 Mc/s, which in terms of digits gives a coverage of -1 to +11 (rather than 0-9). These overlaps are convenient for searching.

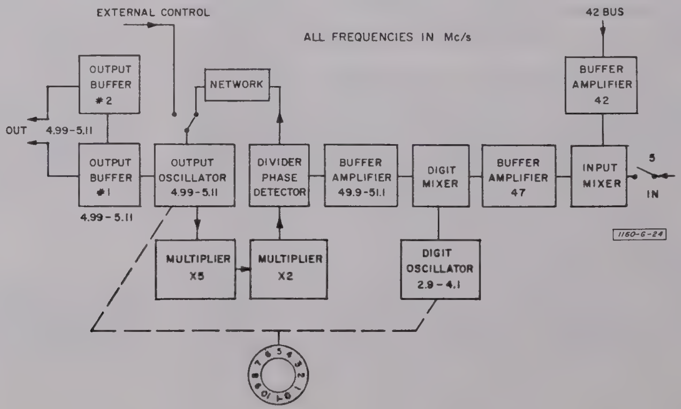

EXTERNAL CONTROL
ALL FREQUENCIES IN Mc/s
42 BUS
OUTPUT BUFFER #2
NETWORK
BUFFER AMPLIFIER 42
OUT
4.99-5.11
OUTPUT BUFFER #1
OUTPUT OSCILLATOR 4.99-5.11
DIVIDER PHASE DETECTOR
BUFFER AMPLIFIER 49.9-51.1
DIGIT MIXER
BUFFER AMPLIFIER 47
INPUT MIXER
5
IN
4.99-5.11
MULTIPLIER X5
MULTIPLIER X2
DIGIT OSCILLATOR 2.9-4.1
1160-G-24

Figure EA-2.
Block diagram of CAD set for **INTERNAL LOCK** mode operation.

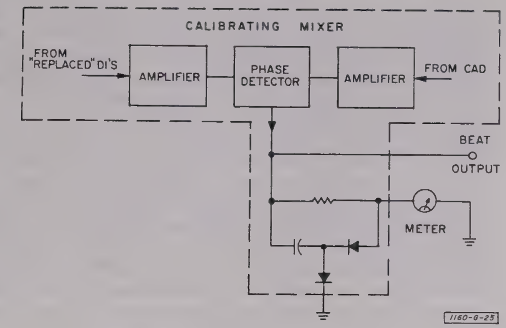


Figure EA-3.
Block diagram for Calibrating Mixer – CM-1.

EA-2.1.3 INTERNAL LOCK MODE.

Two-figure accuracy on the CAD dial calls for parts-in-10^5 oscillator stability. In order to attain such performance, the phase-lock capability available in the 5.0-Mc oscillator, just described, is used in a second operating mode, the INTERNAL LOCK mode. Here oscillator stability is increased by approximately a factor 10. To do this the major part of the output frequency is crystal controlled (47 Mc/s) and only a small part stems from a free-running Digit Oscillator (2.9 – 4.1 Mc/s). The circuit is very similar to one in the DI-1 and uses the same crystal-controlled frequencies produced in the AFS.

The block diagram shows the same input circuits as used in the DI, where 5.0 and 42 Mc/s are added and fed to a second mixer via an amplifier. Instead of heterodyning with a 3.00 – 3.90-Mc step-tuned, phase-locked oscillator, a 2.900 – 4.100-Mc oscillator, tuned by the second section of the ganged capacitor mentioned earlier, is used. The mixer output of 49.90 – 51.10 Mc/s is routed to a phase detector through a double-tuned amplifier, and the same process of division is used as described for the DI-1. The varactor used for external control of the 5.0-Mc oscillator can also be used to phase-lock the oscillator, totally eliminating its instability. Drifts of the 2.9 – 4.1-Mc oscillator are divided by 10.

A second output amplifier feeds the Calibrating Mixer, which is covered in paragraph 2.1.4.

EA-2.1.4 CALIBRATING MIXER – CM-1.

This mixer is a convenient means of checking the accuracy of the CAD frequency. As will be recalled, the CAD replaces all DI-1's to the right and the one above any depressed front-panel button. The replaced DI-1's are no longer contributing to the synthesizer output, but they are operative. The Calibrating Mixer allows comparison of the CAD output with the locked frequency of these DI's.

Figure EA-3 shows that this mixer consists of two amplifiers and a phase detector (see also the schematic diagram, Figure EA-13). The front-panel meter can be connected to this mixer to display slow beats directly. An additional network gives a meter indication (proportional to frequency) for beat frequencies above a few hundred cycles, so that zero beat may be found by first tuning for a minimum on the meter. A one-cycle beat represents an inaccuracy of 1 in the fifth position, so that a calibration to four meaningful figures is possible.

The mixer output is also available on front-panel binding posts; it is particularly useful in the generation of markers for calibration of sweep displays.

The interconnection of the two modules is shown in the schematics of Sections BA and BB.

EA-2.2 CIRCUIT DETAILS.

EA-2.2.1 INTRODUCTION.

Circuit operations and the location of prominent components will be discussed in the sequence in which the signal originates and passes through a Continuously Adjustable Decade and the Calibrating Mixer. Reference will be made to the Figures EA-2 and EA-3, as well as the over-all schematic diagrams Figure EA-11 and EA-13.

EA-2.2.2 OUTPUT-OSCILLATOR/AMPLIFIER.

This section is used in the EXTERNAL CONTROL mode directly. In the INTERNAL LOCK mode, it is used in conjunction with other circuitry in the CAD.

The output signal of 4.99 – 5.11 Mc/s is generated in a Colpitts oscillator (Q401). The tuned circuit includes C102, the variable capacitor operated by the dial control, the varactor diode CR401, for voltage control of the oscillator frequency, and a trimmer C406. The main output amplifier, Q402, is a broadly tuned common-emitter stage loosely coupled to the oscillator. The output voltage of approximately 0.30 V is fed to J404, the output of the CAD unit. The output signal is also applied to Q403, which is an untuned buffer amplifier feeding the Calibrating Mixer through J403.

The output circuits described above occupy the bottom circuit board located behind the ganged capacitor.

EA-2.2.3 INPUT SECTION.

A grounded-emitter stage, Q207, with a tuned output coil, serves as isolator, amplifier, and impedance transformer for the 42-Mc signal that is taken from the 42-Mc bus (fed by the AFS through J401) and injected into the Input Mixer. The input of the 42-Mc buffer is of moderately high impedance and broadly tuned.

In the INTERNAL LOCK mode, the Input Mixer combines the incoming 5.0-Mc signal from J101 and the 42-Mc signal from the buffer. The 5.0-Mc input, of approximately 0.30 V, is stepped-up in T201 and applied to Q201 and Q202. The connection between L207-4 and T201-1 feeds the 42-Mc signal to the transistors in phase and also completes the bias circuit. The balanced configuration, together with the circuit (T202, C204, C205) tuned to the upper sideband (47 Mc/s), effectively eliminates the 42-Mc component in the output and provides substantial rejection for the ninth-harmonic component of the 5-Mc input signal. Q203 is a transformer-coupled buffer-amplifier, which amplifies the 47-Mc signal before application to the Digit Mixer. Its tuned output coil, L202, contributes further selectivity for the suppression of unwanted mixer-output components.

The input circuits described above occupy the front part of the top circuit board.

EA-2.2.4 DIGIT OSCILLATOR, MIXER, AND BUFFER.

A tap on L202 brings the 47-Mc signal from the Q203 buffer stage to the junction of C214 and C215, which forms the input to the Digit Mixer. The second signal into this mixer is the Digit Oscillator output of 2.9 – 4.1 Mc/s. Although continuously tuned in the CAD unit, the term Digit Oscillator is used here too because of the analogy with the Digit Oscillator in the DI-1 unit.

Q208 is the active element in the Digit Oscillator, which includes T205, C234, and C233. Tuning is effected by C101, in the main section of the ganged capacitor, and trimmer C103, located on the front board. The two-phase oscillator output is applied to the Digit Mixer via R220 and R221.

The Digit Mixer output of 49.9 – 51.1 Mc/s (47 + 2.9 to 4.1 Mc/s) is filtered in the tuned circuit T203/C213 and applied to the following buffer, Q206. To obtain an equalized output over the 1.2-Mc bandwidth, a double-tuned filter (compensating the response of the preceding single-tuned circuit) couples the signal into the Divider Phase Detector.

The Digit Oscillator, Digit Mixer and buffer circuits are located on the top board in the middle.

EA-2.2.5 MULTIPLIER CIRCUITS AND PHASE LOCK.

The back board in the CAD unit contains the X10 Multiplier circuits for the output-oscillator frequency.

The two transistors, Q302 and Q301, perform the function of a quintupler and doubler, respectively. Both are class-C multipliers with circuits tuned to the desired harmonic of the input frequency in the collector circuits. L301 and L302 are resonated at approximately 25 Mc/s and T301/T204 are tuned to about 50 Mc/s.

The above circuits, from the Output Oscillator through the Multiplier into the Divider Phase Detector (a conventional half-bridge circuit), and from its output through filter circuits back to the varactor diode (CR401), form a phase-lock circuit. Once captured, the oscillator frequency is kept at exactly 1/10th of the reference frequency (49.9 – 51.1 Mc/s) by a dc voltage applied to the varactor diode. This voltage is developed in the phase detector. If a different dc voltage is required on the varactor diode, to compensate for circuit drifts in the oscillator for instance, only the relative phases of the two inputs to the phase detector change.

Potentiometer R102, an externally accessible control at the top of the unit, sets the initial back-bias for the varactor diode and therefore affects the free-running oscillator frequency.

During the process of "capture" (the synchronization of the oscillator frequency with the reference frequency), the oscillator is frequency-modulated initially with the frequency difference between the reference and its own frequency multiplied by ten. Sidebands of this modulation have to be passed by the multiplier circuits and they are therefore considerably wider in bandwidth than 4.99 – 5.11 Mc/s (or 49.9 – 51.1 Mc/s) would suggest.

EA-2.2.6 FRONT CIRCUIT BOARD.

Reference has been made in various paragraphs above to the front circuit board, which contains the mode switch, S402, potentiometers R102 and R105, trimmer C103, and various associated parts.

The mode switch (lever on the right of the CAD dial with coaxial actuator), as has been mentioned before, selects one of the two operating modes of the CAD according to the desired application.

If frequency control by external voltage is desired, the EXTERNAL CONTROL mode is selected and only the Output-Oscillator amplifier section of the CAD is activated. The switch removes the 5-Mc input from T201, connects the EXTERNAL CONTROL voltage from J102 through filtering circuits to one side of the varactor diode, CR401. R105 permits adjustment of the sensitivity for external frequency control to a nominal value of -0.3 V for plus one major CAD division (10 kc/s). The cathode terminal of the varactor is connected to R102, establishing the back bias. Besides electronic frequency control, the dial (through C102) is used to set the frequency of the CAD.

In the INTERNAL LOCK mode, R104 keeps the anode of the varactor at ground potential, while the cathode is connected to the Divider Phase-Detector output. Since the 5-Mc input signal is now also connected, the output oscillator is phase-locked through the X10 multiplier to the 49.9 – 51.1-Mc reference signal. It is easily seen that a 100-kc change in the Digit Oscillator produces a 10-kc change in the output oscillator, and that digit-oscillator drift is reduced in the same way. The output oscillator, which is now only pretuned by C102 (ganged with C101), does not contribute to the output frequency instability in this mode.

EA-2.2.7 CALIBRATING MIXER – CM-1.

Schematic diagram Figure EA-13 shows the CAD Calibrating Mixer employing two amplifiers, Q101 and Q102 (in the grounded-emitter configuration), and a half-bridge mixer. The amplifiers supply the power gain needed to drive the meter circuit, while maintaining isolation to prevent a feedthrough from the "Mix" or Reference-Line fed by the replaced DI-1's to the CAD output.

CAD output #2 is present continuously at pin A_1 of PL101 of the CM-1 unit. The output frequency of the replaced DI-1's enters at pin F6 of PL101, whenever the CAD is activated. When both inputs are present simultaneously, the CM-1 compares them and the result of the comparison is its output.

The Mixer Output is dc-connected to the BEAT terminals on the front panel, where it may be used for calibration, marker generation, or phase locking.

The MONITOR meter (through the front-panel switch) is connected to the Mixer Output, to display slow-beat frequencies between the CAD frequency and the frequency of the replaced DI-1 units. As an aid in finding the slow beat, a frequency-sensitive detector circuit is inserted to rectify the beat frequency and produce a meter deflection to the right that increases with frequency.

SECTION EA-3

SERVICE AND MAINTENANCE

EA-3.1 INTRODUCTION.

EA-3.1.1 GENERAL.

Just as the CAD unit can be used in the system self-check procedures (refer to paragraph 5.3) to test the DI-1 modules, properly functioning DI-1 units and the AFS unit can serve in a synthesizer to test the CAD, when used in conjunction with the Calibrating Mixer. Many such tests can be performed without instrument disassembly. As will be recalled, the Calibrating Mixer compares the output frequency of the CAD unit directly with the output of one or a series of several DI-1 units.

EA-3.1.2 TEST EQUIPMENT.

Table EA-1 lists and describes tools and test equipment recommended for the procedures which follow in this section. Equivalents may be substituted.

TABLE EA-1
TEST EQUIPMENT

Function	*Type Recommended*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806-A (with Type 1806-P1 probe)	BW 1-55 Mc/s; sensitivity 0.2 V; probe capacity 2.0 pF maximum.
Voltage source, variable	———	0-2 Vdc continuous; 1.0 mA, minimum; internal resistance <10Ω.
Patch cord	274-NQ	Coaxial, double plug for binding post.
Adjustment tool	JFD #5284	Minimum metallic contact with screw slot; insulated shaft.

EA-3.2 TROUBLE ANALYSIS – EXTERNAL.

EA-3.2.1 GENERAL.

External service procedures do not require removal of the CAD or CM-1 modules from the Main Frame chassis, but do require that the synthesizer be removed from its cabinet and be set up in normal operating position, with usual line-power input. Front-panel controls and indicators on the synthesizer (assumed to be otherwise in good working order) will suffice at this level.

There are two basic failure modes possible in the CAD and CM-1. They are:

1. Output missing or low.
2. Poor frequency control.

NOTE

Unless the CAD is used as the electrical "replacement" of the left-most DI-1 unit, absence of the CAD output will not result in loss of synthesizer output.

EA-3.2.2 OUTPUT MISSING OR LOW.

Lack of CAD output is detected most easily by absence of front-panel MONITOR meter deflection. Check this in the CAD-CAL mode, as the CAD frequency is adjusted by the dial, with the button under the CAD unit depressed. A meter reading in this condition indicates that the CAD produces an output.

If no meter deflection can be obtained, a further convenient check can be made to isolate the trouble between the CAD and the Calibrating Mixer (CM-1).

Depress the button under the left most DI-1 unit (station 1) and observe the signal at TP102 with the VTVM. TP102 is accessible on the left-hand side pan of the synthesizer chassis. A reading of 0.3 V, rms, at approximately 5 Mc/s (with the CAD dial set at 0) should be obtained.

If the reading is normal, the CAD is probably functioning properly and the CM-1 is defective; refer to paragraph EA-3.7 for detail trouble analysis on that unit. There is also the possibility that Output Buffer #2 in the CAD is faulty. To distinguish between this and a CM-1 failure, remove the CM-1 and connect the VTVM to pin 1 of SO201 on the Main Frame deck. A voltage of approximately 0.3 V, rms, should be present. If the reading is abnormal, proceed to the internal trouble-analysis procedures for the CAD, paragraph EA-3.4.

EA-3.2.3 POOR FREQUENCY CONTROL.

With the button under the CAD depressed and the digit steps set to 0, a variation of the CAD frequency-dial setting, near the zero mark, should produce a minimum in the meter indication. By careful further adjustment, a visible beat of a few cycles per second should be obtained. In the EXTERNAL CONTROL mode, deviations from the zero dial setting up to ±3 small divisions may be required, depending upon instrument temperature. In the INTERNAL LOCK mode, the beat should be obtained within ±0.5 small divisions from zero. If beat cannot be achieved within these limits, refer to paragraph EA-3.3 for corrective adjustments.

EA-3.3 EXTERNAL ADJUSTMENTS.

EA-3.3.1 GENERAL.

Three secondary controls, accessible through the cover of the CAD unit, can be adjusted with an insulated screwdriver, with the unit remaining in its normal operating position on the synthesizer. If either of the following procedures cannot be completed successfully, refer to paragraph EA-3.4.

EA-3.3.2 MANUAL CONTROL.

CAD oscillator drift may necessitate adjustment of frequency to re-establish exact correlation with the dial. After the instrument cabinet has been removed, R102 and C103 are accessible through the top of the CAD cover. The procedure is as follows:

a. Compare the CAD output frequency with that of the neighboring DI-1 unit in the "5" position, by pressing the button under that DI-1 and setting the MONITOR switch to the CAD-CAL position.

b. Place the mode selector in the EXTERNAL CONTROL position and set the dial to 5.00.

c. Adjust R102 to obtain a slow beat (<10 c/s) on the meter.

d. Repeat the procedure in the INTERNAL LOCK mode, except use C103 for the adjustment.

EA-3.3.3 ELECTRICAL CONTROL.

The EXTERNAL CAD CONTROL voltage sensitivity can be adjusted by use of R105, which is accessible through a cutout in the adjacent side pan of the Main Frame chassis. After setting R102 in accordance with paragraph EA-3.3.2, proceed as follows:

a. Set the DI-1 (next to the CAD) to digit "6".

b. Apply a voltage of -0.3 Vdc, from the external source to the EXTERNAL CAD CONTROL binding post.

c. Look for a slow beat on the meter.

d. Adjust R105 for a minimum meter indication and, with careful adjustment, achieve a slow beat (<10 c/s).

EA-3.4 CAD TROUBLE ANALYSIS – INTERNAL.

EA-3.4.1 GENERAL.

If the CAD output is abnormal, or poor frequency control cannot be compensated by the adjustment procedures of paragraph EA-3.3, remove the unit from the chassis and replace it with another CAD, if available. Otherwise, replace it with a CAD bridging unit or equivalent; refer to paragraph 5.5 in the front portion of the book. Return the defective CAD to General Radio Company for service.

If the faulty CAD unit cannot be returned, certain further tests can be made in the field. However, a thorough comprehension of the principles of operation (Section EA-2) is essential. The following procedures will permit isolation of the fault within the CAD, so that corrective measures can be taken. Turn instrument power off and remove the CAD unit from the synthesizer to permit cover removal; refer to paragraph EA-3.5. Remove the two screws in each side of the unit to release the cover. Grasp the tuning-control shaft in one hand and pull the cover off the back of the unit with the other.

Reinstall the open CAD on the synthesizer and remount the mode-switch lever in the EXTERNAL CONTROL position. Make sure that the tuning dial is at its fully CW position and remount the dial knob so that it reads exactly 11.

Turn power on and follow the procedural steps given in Table EA-2 to isolate trouble to a defective stage. At that point, reference to Table EA-3 should also aid in isolation of a defective detail part.

The test points called out are identified in Figures EA-4 and EA-5; for the most part they are accessible along the top of the module. Those few required test points that are not on the top are accessible through the opening in the right-hand side pan of the synthesizer chassis.

CAUTION

Do not bend the plates of C101 or C102 and do not short the +18-V supply to ground with the VTVM probe.

Synthesizer controls must be placed in the following setting before the procedures of Table EA-2 are undertaken:

POWER – on
MONITOR – CAD CAL
Step digits – 0 (all units)
CAD mode – INTERNAL LOCK
CAD dial – 5.00
CAD pushbutton – depressed

EA-3.5 REMOVAL OF CAD FROM CHASSIS.

CAUTION

The power switch must first be OFF, or preferably, the power cord should be disconnected.

Each CAD unit is held in place by two front-panel screws (concealed under the dial strip at the top of the panel) and by a hold-down clamp in the deck at the

TABLE EA-2

CAD INTERNAL TROUBLE ANALYSIS
(Figure EA-4, EA-5 and EA-11)

Step	*Circuit*	*Test Point*	*Normal Indication**	*If Indication Abnormal*
1	B+	AT209	18 ±0.2 Vdc	Check Main Frame and Power-Supply module.
2	Output Oscillator	TP401 (C102 rotor)	6.5-8.5 V, rms	Refer to Table EA-3.
3	5-Mc Input	AT204	0.25-0.40 V, rms	Check Main Frame and AFS module.
4	42-Mc Input	AT201	0.8-1.1 V, rms	Check Main Frame and AFS module.
5	42-Mc Buffer	TP201	0.4-0.8 V, rms	Refer to Table EA-3.
6	Input Mixer	TP202	0.5-0.7 V, rms	Refer to Table EA-3.
7	47-Mc Buffer	TP203	2.5-3.5 V, rms	Refer to Table EA-3.
8	Digit Oscillator	TP205	11-14 V, rms	Refer to Table EA-3.
9	Digit Mixer	TP206	0.4-0.7 V, rms	Refer to Table EA-3.
10	49.9-51.1 Mc Buffer	TP207	5.0-6.0 V, rms	Refer to Table EA-3.
11	X5 Multiplier	TP301	1.8-2.3 V, rms	Refer to Table EA-3.
12	X2 Multiplier	TP208	3.0-5.0 V, rms	Refer to Table EA-3.

*All taken with Type 1806-A with Type 1806-P1 probe.

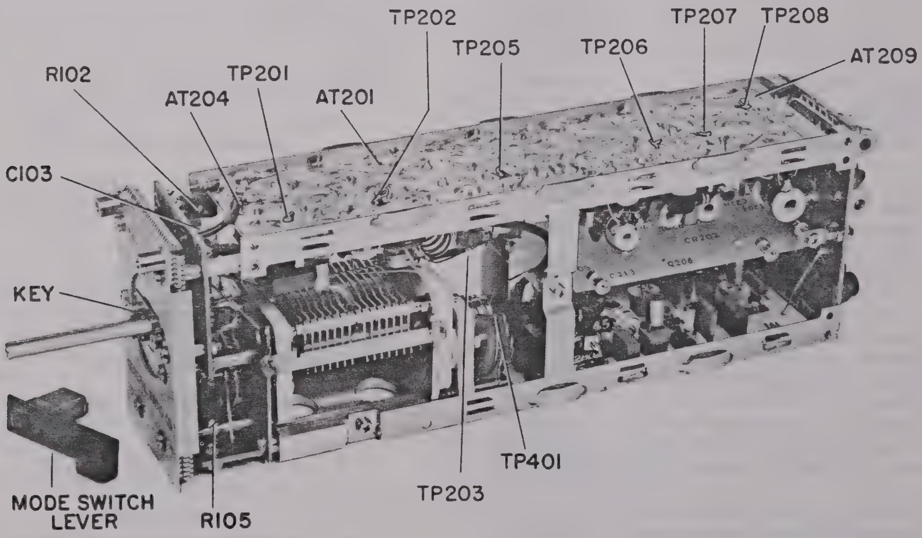

TP202
TP207
TP208
TP205
TP206
AT209
R102
TP201
AT204
AT201
C103
KEY
MODE SWITCH LEVER
R105
TP203
TP401

Figure EA-4. Front oblique view of CAD, top side.

TABLE EA-3

CAD DC VOLTAGE READINGS

Stage	*Emitter*	*Base*	*Collector*
Q201	17.9	17.2	0
Q202	17.9	17.2	0
Q203	0.95	1.46	17.5
Q204	0.8	-.1	17.7
Q205	0.8	-.1	17.7
Q206	1.60	1.95	17.3
Q207	0.75	1.35	17.8
Q208	15.8	16.0	0
Q301	2.5	0	17.0
Q302	2.6	0	17.3
Q401	16.1	16.1	0
Q402	17.3	17.0	0
Q403	16.7	16.4	10.0

NOTES:

Unit operating with all inputs, installed in chassis, no cover.

Voltages measured in the INTERNAL LOCK mode with Type 1806-A in dc positions.

These are typical readings and they are somewhat dependent on rf signal levels.

Variations of ±15% are to be expected.

rear of the unit. To remove the unit, proceed as follows:

a. Remove the dial strip, which is held in place by the two Phillips-head screws.

b. Loosen the two Allen-head setscrews in the knob, by use of a 3/32-inch hex wrench, and remove the dial. Then pull the dial lamp holder forward out of the panel. (There is a threaded insert in the top center of the lamp holder into which a 4-40 screw can be inserted to serve as a handle).

c. Pull the EXTERNAL CONTROL/INTERNAL LOCK switch lever off the shaft.

d. Release the rear clamp, using a straight-bladed screwdriver in the slot of the clamp screw. Turn counterclockwise until the clamping bar swings out of the recess in the rear of the unit. (To reinstall the unit, it may be necessary to take an additional turn or two counterclockwise, in order to raise the clamping bar high enough to swing freely into the recess, when the clamp screw is tightened clockwise.)

e. Grasp the unit by its shaft and at the rear and lift vertically for about 5/8 inch until the banana plugs are disengaged. Then continue to raise the rear and angle the unit out.

CAUTION

Position the mode switch at EXTERNAL CONTROL before removal or remount; otherwise, the leaf-spring contact which controls lamp dimming may be damaged.

NOTE

To reinstall the CAD dial, turn the shaft clockwise to the stop. Then install the dial to read "11" (i.e., set the dial line marked "10" at the lamp holder dial line marked "1", for proper dial registration).

EA-3.6 REPAIR AND REPLACEMENT.

If the CAD internal-trouble-analysis procedures disclose defective detail parts, turn off synthesizer power, dismount the CAD, and remove the defective parts. It should not be necessary to disassemble the unit further, to remove replaceable parts.

NOTE

In any event, replacement must be limited to non-frequency determining parts, because special fixtures are required to permit realignment of tuned circuits that have been altered.

Figure EA-5 shows the relative positions of the four etched-circuit boards upon which most CAD parts are mounted. Callouts on that figure refer to composite views of the circuit boards (which are presented in Figures EA-7 through EA-10) that give the exact locations of the parts.

Reference designators used on the photos and printed on the circuit boards are the same as those appearing on the over-all schematic diagram, Figure EA-11, and used in the parts list given at the end of this section.

EA-3.7 CM-1 SERVICE.

EA-3.7.1 GENERAL.

If a 0 (center-scale) deflection on the front-panel MONITOR meter could not be obtained, as called for in paragraph EA-3.2.3, and the CAD has been determined to be in proper operating condition, the Calibrating Mixer is out of adjustment or has defective parts. Procedures that follow should permit satisfactory readjustment, or facilitate isolation of the defective circuit for repair or replacement. Refer to Figures EA-12 and EA-13; reference to the schematic diagrams for the appropriate Main Frame (Section BA or BB) should also prove helpful for interconnecting wiring between modules.

EA-3.7.2 BALANCE ADJUSTMENT.

With the MONITOR meter switch in the CAD CAL position, the CAD OFF pushbutton depressed, and the CAD dial set at 0, adjust R105, accessible through the top of the CM-1 cover, for a 0 meter indication. If the R105 adjustment does not accomplish the desired effect, continue below.

EA-3.7.3 DETAIL TROUBLE ANALYSIS (Figure EA-6).

To isolate malfunction to a particular stage of the Calibrating Mixer, the unit must first be removed from the synthesizer and its primary inputs checked.

CAUTION

Do not remove or install a CM-1 with synthesizer power on.

To do this, proceed as follows:

a. Release the three hold-down screws and pull up on the unit to unplug it from SO201, its multipin connector on the top deck of the Main Frame chassis.

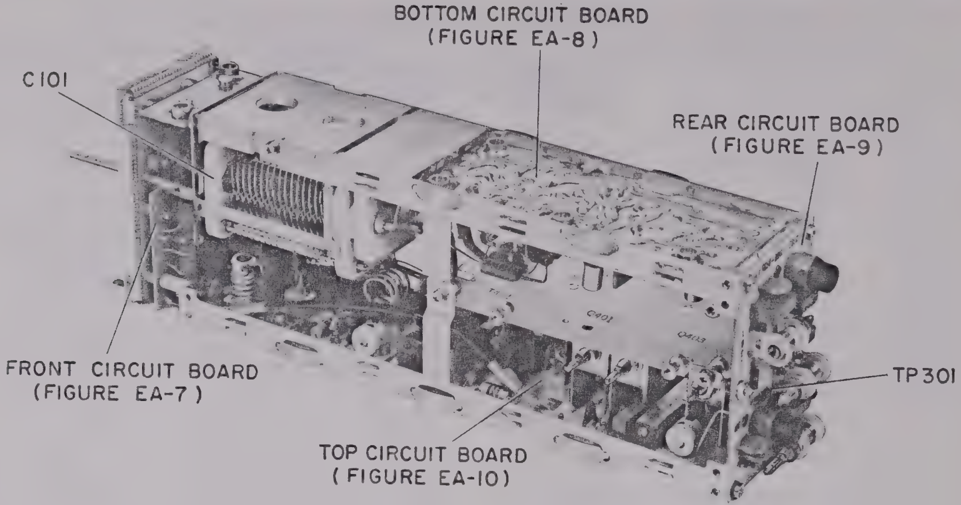

BOTTOM CIRCUIT BOARD (FIGURE EA-8)
C101
REAR CIRCUIT BOARD (FIGURE EA-9)
FRONT CIRCUIT BOARD (FIGURE EA-7)
TP301
TOP CIRCUIT BOARD (FIGURE EA-10)
Q401
Q403

Figure EA-5. Rear oblique view of CAD, bottom side up.

b. Substitute the CAD for any DI-1 module by operation of the appropriate front-panel pushbutton.

c. With the VTVM, measure voltages at three pins on the vacant SO201 (with respect to chassis ground):

pin 1 ---- ≈0.20 to 0.35 V, rms
pin 6 ---- ≈0.30 to 0.45 V, rms
pin 2 ---- +18 ±0.2 Vdc

NOTE

Rotate the digit-selector control of the "replaced" DI-1 through all positions when observing the input at pin 6. If the signal drops out at any position, the trouble is not in the CM-1 but in the DI-1 or the Main Frame (refer to Sections DA and BA or BB).

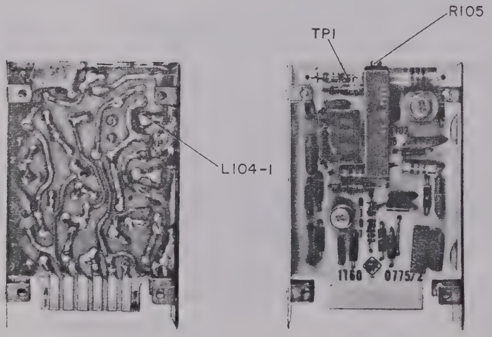


Figure EA-6.
Calibrating Mixer internal test points and secondary adjustments.

TABLE EA-4

CM-1 DC READINGS
(Figure EA-12)

Stage	*Emitter*	*Base*	*Collector*
Q101	14.6	14.3	0
Q102	14.6	14.3	0

NOTES:
Unit installed in chassis, operating without cover.
Meter – Type 1806-A dc position.
Reading variations of ±10% are to be expected.

If the above voltages are normal, the fault must be in the Calibrating Mixer, intermodule wiring, or in the MONITOR meter circuit.

To isolate defects within the CM-1 unit proceed as follows:

a. Remove the eight 4-40 screws that attach the cover to module and slide the cover off.

b. Plug the module into SO201, with the component side of the board facing the front of the synthesizer.

c. Depress the CAD OFF button and look for 3.0 to 4.0 V, rms, at TP1, the junction of CR101, CR102 and L103.

d. Depress the button under any DI-1 unit and look for 3.0 to 4.0 V, rms, at terminal 1 of L104 (accessible from the foil side).

If either of the above indications is abnormal (with proper inputs present to the module), refer to Table EA-4 to check the dc operating voltages at the transistor stages.

EA-3.7.4 REPAIR AND REPLACEMENT.

Repair or replace defective parts. Use Figures EA-6, EA-12 and EA-13, together with the parts list for the CM-1 unit, to identify detail parts.

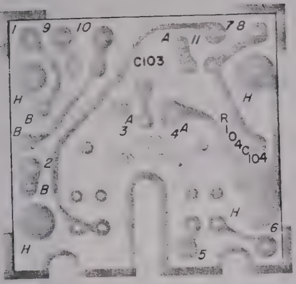

1
9
10
A
11
7 8
C103
H
B
A
3
4
R
104
C104
2
H
6
5

Figure EA-7.
CAD front etched-circuit board (P/N 1160-2780).

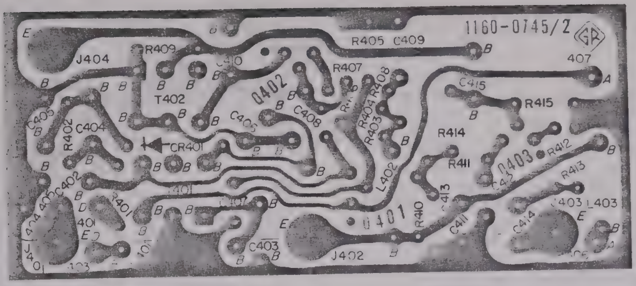

1160-0745/2
GR
E
J404
R409
R405 C409
R407
407
A
T402
Q402
C408
R404
R403
C415
R415
R414
R411
Q403
R412
R413
C404
R402
CR401
L402
C402
401
R401
C403
J402
Q401
R410
C411
C413
C414
L403
B

Figure EA-8.
CAD bottom etched-circuit board assembly (P/N 1160-2746).

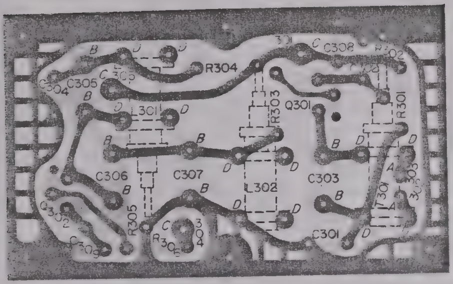

C308
R302
R304
C305
C304
L301
Q301
R303
R301
C306
C307
C303
L302
R305
R306
C301
C302
C309
B
D

Figure EA-9.
CAD rear etched-circuit board assembly (P/N 1160-2735).

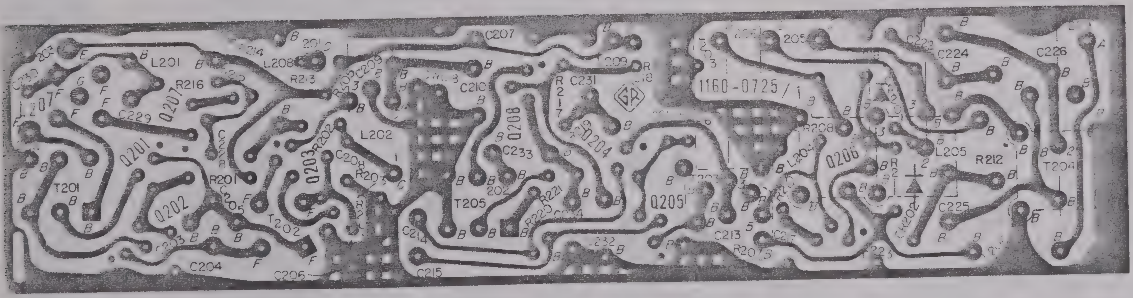

C207
L201
L208
R216
R213
C209
C210
C231
1160-0725/1
GR
C224
C226
C222
L207
C229
Q207
Q201
Q202
T201
R201
L202
Q203
C208
T202
C204
C206
C212
C215
Q208
C233
Q204
T205
R221
R222
Q205
R208
Q206
L204
L205
R212
T204
C225
CR202
C213
R207
T223
B
F
A

Figure EA-10.
CAD top etched-circuit board assembly (P/N 1160-2726).

NOTE: The number appearing on the foil side is not the part number.

PARTS LIST

CAPACITORS

REF NO	DESCRIPTION	PART NO
C101	Variable, ganged	Part of 1160-2900
C102	Variable, ganged	Part of 1160-2900
C103	Trimmer, 5.5 to 18 pF 350 V	Part of 1160-2900
C104	Ceramic, 0.001 µF +80-20% 500 V	Part of 1160-2900
C105	Ceramic, 0.022 µF +80-20% 500 V	Part of 4407-3329
C201	Mica, 590 pF ±2% 300 V	4700-0730
C202	Mica, 590 pF ±2% 300 V	4700-0730
C203	Ceramic, 470 pF ±10% 500 V	4404-1478
C204	Trimmer, 7 to 25 pF 350 V	4910-2032
C205	Mica, 100 pF ±2% 500 V	4650-0201
C206	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C207	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C208	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C209	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C210	Mica, 62 pF ±5% 500 V	4700-0364
C211	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C212	Ceramic, 0.001 µF +80-20% 500 V	Part of 1160-2231
C213	Trimmer, 7 to 25 pF 350 V	4910-2032
C214	Mica, 22 pF ±10% 500 V	4620-0151
C215	Mica, 22 pF ±10% 500 V	4620-0151
C216	Ceramic, 0.001 µF +80-20% 500 V	Part of 1160-2231
C217	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C218	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C219	Mica, 33 pF ±5% 500 V	Part of 1160-2271
C220	Ceramic, 1 pF ±10% 500 V	4400-0100
C221	Mica, 33 pF ±5% 500 V	1160-2271
C222	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C223	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C224	Mica, 10 pF ±5% 500 V	4700-0203
C225	Mica, 10 pF ±5% 500 V	4700-0203
C226	Trimmer, 7 to 25 pF 350 V	4910-2032
C227	Mica, 33 pF ±5% 500 V	Part of 1160-2211
C228	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C229	Mica, 90.0 pF ±2% 500 V/	4650-0170
C230	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C231	Ceramic, 0.47 µF ±20% 25 V	4400-2054
C232	Ceramic, 0.02 µF +80-20% 50 V	4402-3200
C233	Ceramic, 56 pF ±5% 500 V (N330)	4415-0565
C234	Mica, 0.0015 µF ±5% 100 V	4700-0690
C301	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C302	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C303	Mica, 27 pF ±5% 500 V	4700-0235
C304	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C305	Mica, 82 pF ±5% 500 V	4700-0382
C306	Mica, 12 pF ±5% 500 V	4700-0205
C307	Mica, 120 pF ±5% 500 V	4700-0426
C308	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C309	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C401	Ceramic, 33 pF ±5% 500 V (N470)	4416-0335
C402	Mica, 0.001 µF ±5% 300 V	4700-1190
C403	0.01 µF ±10% 200 V	1160-0420
C404	Mica, 33 pF ±5% 200 V	4700-0301
C405	Mica, 220 pF ±5% 500 V	4700-0519
C406	Trimmer, 5.5 to 18 pF 350 V	4910-2031
C407	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C408	Ceramic, 1.5 pF ±10% 500 V	4400-0159
C409	Ceramic, 0.22 µF ±20% 25 V	4400-2052
C410	Mica, 220 pF ±5% 500 V	4700-0519
C411	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C412	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C413	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C414	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C415	Mica, 22 pF ±10% 500 V	4700-0229

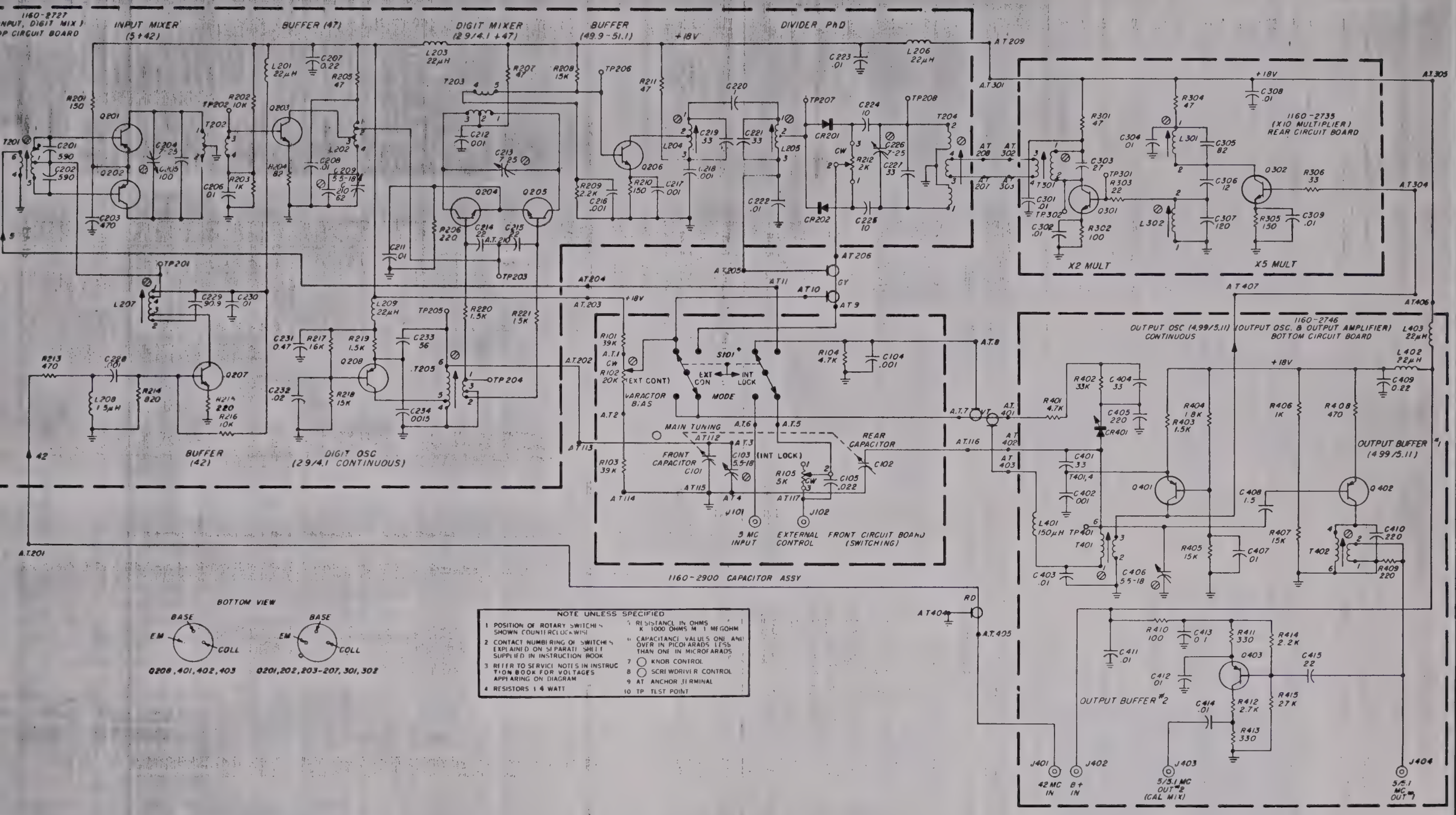
INDUCTORS

REF NO	DESCRIPTION	PART NO
L201	Choke, rf, 22 µH ±10%	4300-2600
L202	Coil, air core	1160-2280
L203	Choke, rf, 22 µH ±10%	4300-2600
L204	Adjustable, ceramic	1160-2270
L205	Adjustable, ceramic	1160-2270
L206	Choke, rf, 22 µH ±10%	4300-2600
L207	Adjustable, ceramic	1160-2380
L208	Choke, rf, 1.5 µH ±10%	4300-1000
L209	Choke, rf, 22 µH ±10%	4300-2600
L301	Adjustable, ceramic	1160-2330
L302	Adjustable, ceramic	1160-2340
L401	Choke, rf, 150 µH ±10%	4300-3810
L402	Choke, rf, 22 µH ±10%	4300-2600
L403	Choke, rf, 22 µH ±10%	4300-2600

RESISTORS

REF NO	DESCRIPTION	PART NO
R101	Composition, 39 kΩ ±5% 1/4 W	6099-3395
R102	Potentiometer, wire-wound 20 kΩ ±10%	Part of 1160-2900
R103	Composition, 39 kΩ ±5% 1/4 W	Part of 1160-2900
R104	Composition, 4.7 kΩ ±5% 1/4 W	Part of 1160-2900
R105	Potentiometer, wire-wound 5 kΩ ±10%	Part of 1160-2900
R201	Composition, 150 Ω ±5% 1/4 W	6099-1155
R202	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R203	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R204	Composition, 82 Ω ±5% 1/4 W	6099-0825
R205	Composition, 47 Ω ±5% 1/4 W	Part of 1160-2271
R206	Composition, 220 Ω ±5% 1/4 W	6099-122
R207	Composition, 47 Ω ±5% 1/4 W	Part of 1160-22
R208	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R209	Composition, 2.2 kΩ ±5% 1/4 W	Part of 1160-2231
R210	Composition, 150 Ω ±5% 1/4 W	6099-1155
R211	Composition, 47 Ω ±5% 1/4 W	6099-0475
R212	Potentiometer, composition 2 kΩ ±10%	6057-2209
R213	Composition, 470 Ω ±5% 1/4 W	6099-1475
R214	Composition, 820 Ω ±5%	6099-1825
R215	Composition, 150 Ω ±5% 1/4 W	6099-1155
R216	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R217	Composition, 1.6 kΩ ±5% 1/4 W	6099-2165
R218	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R219	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R220	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R221	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R301	Composition, 47 Ω ±5% 1/4 W	6099-0475
R302	Composition, 100 Ω ±5% 1/4 W	6099-1105
R303	Composition, 22 Ω ±5% 1/4 W	6099-0225
R304	Composition, 47 Ω ±5% 1/4 W	6099-0475
R305	Composition, 150 Ω ±5% 1/4 W	6099-1155
R306	Composition, 33 Ω ±5% 1/4 W	6099-0335
R401	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R402	Composition, 33 kΩ ±5% 1/4 W	6099-3335
R403	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R404	Composition, 1.8 kΩ ±5% 1/4 W	6099-2185
R405	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R406	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R407	Composition, 15 kΩ ±5% 1/4 W	6099-3155
R408	Composition, 470 Ω ±5% 1/4 W	6099-1475
R409	Composition, 220 Ω ±5% 1/4 W	6099-1225
R410	Composition, 100 Ω ±5% 1/4 W	6099-1105
R411	Composition, 330 Ω ±5% 1/4 W	6099-1335
R412	Composition, 2.7 kΩ ±5% 1/4 W	6099-2275
R413	Composition, 330 Ω ±5% 1/4 W	6099-133

Parts List continued on foldout of page EA-16.


1160-2727
NPUT, DIGIT MIX)
OP CIRCUIT BOARD
INPUT MIXER (5+42)
BUFFER (47)
DIGIT MIXER (29/4.1 +47)
BUFFER (49.9-51.1)
+18V
DIVIDER PAD
A.T 209
A.T 301
A.T 305
R201 150
Q201
Q202
T201
C201 590
C202 590
C203 470
C204 7-25
C205 100
T202
TP202
R202 10K
C206 .01
R203 1K
Q203
R204 82
L201 22µH
C207 0.22
R205 47
L202
C208 .01
C209 5.5-18
C210 62
L203 22µH
T203
R207 47
R208 15K
C212 .001
C213 7-25
Q204
Q205
R206 220
C211 .01
C214 22
C215 22
A.T.210
TP203
TP206
R211 47
Q206
R209 2.2K
C216 .001
R210 150
C217 .001
C220 1
L204
C219 33
C221 33
L205
C218 .001
C222 .01
C223 .01
L206 22µH
TP207
CR201
CR202
C224 10
C225 10
C226 7-25
C227 33
R212 2K
CW
TP208
T204
AT 208
AT 207
AT 302
AT 303
TP201
L207
C229 90.9
C230 .01
R213 470
C228 .001
L208 1.5µH
R214 820
Q207
R215 220
R216 10K
BUFFER (42)
42
5
A.T.201
L209 22µH
C231 0.47
R217 16K
R219 1.5K
Q208
C232 .02
R218 15K
C233 56
TP205
T205
C234 .0015
TP204
R220 1.5K
R221 1.5K
DIGIT OSC (29/4.1 CONTINUOUS)
AT204
A.T.203
A.T.202
A T113
A T.205
AT 206
AT11
AT10
AT 9
GY
R101 39K
A.T.1
R102 20K
(EXT CONT)
VARACTOR BIAS
A.T.2
R103 39K
A T114
S101
EXT CON
INT LOCK
MODE
MAIN TUNING
AT112
FRONT CAPACITOR C101
C103 5.5-18
(INT LOCK)
A.T.3
A.T.6
A.T.5
AT115
AT 4
R105 5K
C105 .022
AT117
REAR CAPACITOR
C102
R104 4.7K
C104 .001
A.T.8
J101
J102
5 MC INPUT
EXTERNAL CONTROL
FRONT CIRCUIT BOARD (SWITCHING)
1160-2900 CAPACITOR ASSY
A.T.7
VT
A.T.116
AT 401
AT 402
AT 403
1160-2735 (X10 MULTIPLIER) REAR CIRCUIT BOARD
R301 47
T301
C301 .01
TP302
C302 .01
Q301
R302 100
C303 27
TP301
R303 22
R304 47
C304 .01
L301
C305 82
C306 12
L302
C307 120
Q302
R305 150
C309 .01
R306 33
C308 .01
X2 MULT
X5 MULT
A.T 304
A T 407
A.T.406
OUTPUT OSC (4.99/5.11) CONTINUOUS
1160-2746 (OUTPUT OSC. & OUTPUT AMPLIFIER) BOTTOM CIRCUIT BOARD
L403 22µH
L402 22µH
C409 0.22
R401 4.7K
R402 33K
C404 33
C405 220
CR401
C401 33
T401,4
C402 .001
L401 150µH
TP401
T401
C403 .01
C406 5.5-18
R404 1.8K
R403 1.5K
Q401
R405 15K
C407 .01
C408 1.5
R406 1K
R407 15K
R408 470
OUTPUT BUFFER #1 (4.99/5.11)
Q402
T402
C410 220
R409 220
RD
A T404
A.T.405
R410 100
C411 .01
C413 0.1
R411 330
Q403
C412 .01
R414 2.2K
C415 22
R412 2.7K
R413 330
R415 27K
C414 .01
OUTPUT BUFFER #2
J401
42 MC IN
J402
B+ IN
J403
5/5.1 MC OUT #2 (CAL MIX)
J404
5/5.1 MC OUT #1
BOTTOM VIEW
BASE
EM
COLL
Q208, 401, 402, 403
Q201, 202, 203-207, 301, 302

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS LESS THAN ONE IN MICROFARADS
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

Figure EA-11.
Over-all schematic diagram for the Continuously Adjustable Decade CAD.
(P/N 1160-4020).

PARTS LIST (Cont)

REF NO	DESCRIPTION	PART NO
	RESISTORS (Cont)	
R414	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R415	Composition, 27 kΩ ±5% 1/4 W	6099-3275
	TRANSFORMERS	
T201	Adjustable, ferrite cup	5000-2802
T202	Adjustable, ceramic	1160-2370
T203	Adjustable, ceramic	1160-2230
T204	Ajdustable, ceramic	1160-2210
T205	Adjustable, ferrite cup	5000-2830
T301	Adjustable, ceramic	1160-2350
T401	Adjustable, ferrite cup	5000-2831
T402	Adjustable, ferrite cup	5000-2804
	TRANSISTORS	
Q201	Type 2N2188	8210-1045
Q202	Type 2N2188	8210-1045
Q203	Type 2N2218	8210-1028
Q204	Type 2N708	8210-3089

REF NO	DESCRIPTION	PART NO
Q205	Type 2N708	8210-3089
Q206	Type 2N2218	8210-1028
Q207	Type 2N708	8210-3089
Q208	Type 2N2188	8210-1045
Q301	Type 2N2218	8210-1028
Q302	Type 2N2218	8210-1028
Q401	Type 2N2188	8210-1045
Q402	Type 2N2188	8210-1045
Q403	Type 2N2188	8210-1045
	MISCELLANEOUS	
CR201	Diode, semiconductor, type 1N955	6082-1002
CR202	Diode, semiconductor, type 1N995	6082-1002
CR401	Diode, semiconductor, type 1N953	6084-1006
J101	JACK, Etched-circuit, Part of 1160-2900	1160-6110
J102	JACK, Etched-circuit, Part of 1160-2900	1160-6110
J401	JACK, Etched-circuit, eyelet type	1160-6110
J402	JACK, Etched-circuit, eyelet type	1160-6110
J403	JACK, Etched-circuit, eyelet type	1160-6110
J404	JACK, Etched-circuit, eyelet type	1160-6110

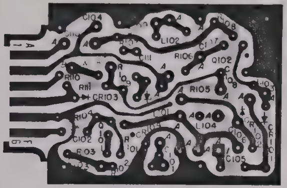
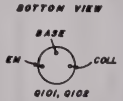

C104
L102
R106
Q102
C111
R110
R111
CR103
R105
C101
L104
R104
C102
R103
C105

Figure EA-12.
Calibrating Mixer module etched-circuit board
(P/N 1160-2775).

NOTE: The number appearing on the foil side is not the part number.

PARTS LIST

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C101	Ceramic, 1 µF ±20% 25 V	4400-2070
C102	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C103	Ceramic, 0.1 µF ±20% 25 V	4400-2050
C104	Ceramic, 1 µF ±20% 25 V	4400-2070
C105	Ceramic, 100 pF ±10% 500 V	4404-1108
C106	Ceramic, 100 pF ±10% 500 V	4404-1108
C107	Ceramic, 0.02 µF +80-20% 50 V	4402-3200
C108	Ceramic, 470 pF ±10% 500 V	4404-1478
C109	Ceramic, 1 µF ±20% 25 V	4400-2070
C110	Mica, 27 pF ±5% 500 V	4700-0235
C111	Ceramic, 0.0047 µF +80-20% 500 V	4405-2479
	RESISTORS	
R101	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R102	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R103	Composition, 100 Ω ±5% 1/4 W	6099-1105
R104	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R105	Potentiometer, composition 5 kΩ ±10%	6057-2509
R106	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R107	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R108	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R109	Composition, 1.2 kΩ ±5% 1/4 W	6099-2125
R110	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R111	Composition, 15 kΩ ±5% 1/4 W	6099-3155
	MISCELLANEOUS	
CR101	Diode, semiconductor, type 1N191	6082-1008
CR102	Diode, semiconductor, type 1N191	6082-1008
CR103	Diode, semiconductor, type 1N191	6082-1008
CR104	Diode, semiconductor, type 1N191	6082-1008
L101	Inductor, choke, rf, 22 µH ±10%	4300-2600
L102	Inductor, choke, rf, 22 µH ±10%	4300-2600
L103	Inductor, choke, rf, 150 µH ±10%	4300-3810
L104	Inductor, Adjustable, ferrite cup	5000-2828
PL101	Plug, multipin, etched-circuit type	1160-2775
Q101	Transistor, type 2N2188	8210-1045
Q102	Transistor, type 2N2188	8210-1045


BOTTOM VIEW
BASE
EM
COLL
Q101, Q102

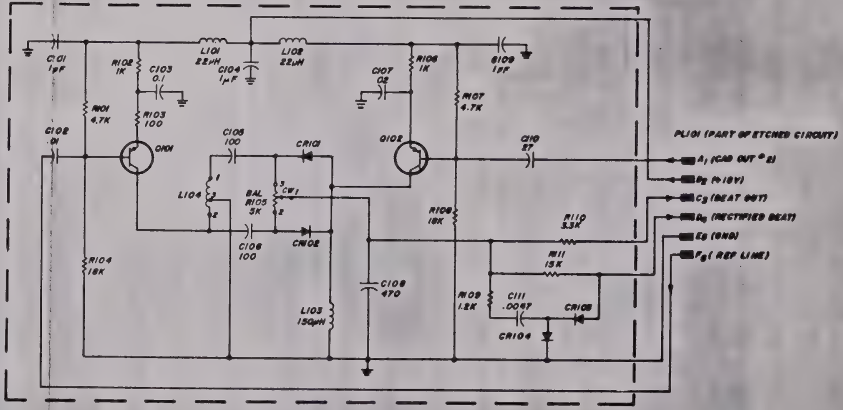

C101 1pF
R102 1K
C103 0.1
L101 22µH
C104 1µF
L102 22µH
R106 1K
C109 1pF
C107 .02
R107 4.7K
R101 4.7K
R103 100
C102 .01
Q101
C105 100
CR101
Q102
C110 27
PL101 (PART OF ETCHED CIRCUIT)
A1 (CAL OUT # 2)
B2 (+10V)
C3 (BEAT OUT)
D4 (RECTIFIED BEAT)
E5 (GND)
F6 (REF LINE)
L104
BAL R105 5K
CW
R108 18K
R110 3.3K
R111 15K
C106 100
CR102
R104 18K
C108 470
L103 150µH
R109 1.2K
C111 .0047
CR103
CR104

Figure EA-13.
Over-all schematic diagram for the Calibrating Mixer CM-1
(P/N 1160-4030).

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT - ANCHOR TERMINAL
10. TP - TEST POINT

SERVICE INSTRUCTIONS

section FA

OUTPUT MIXER, OM-1

P/N 1161-4000
(Used only on Type 1161 Synthesizer)

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Form No. 1161-0140-A ID Number B8 July 1966

GENERAL RADIO COMPANY

West Concord, Massachusetts

SECTION FA-1

INTRODUCTION

FA-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section has been prepared from a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis".

Included in the following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension (by experienced service personnel) of the principles of operation. A trouble-analysis procedure that will aid in isolation of defective circuits completes the section.

To facilitate parts identification, reference designators used in the text and on the photographs are the same as those that appear on the complete schematic diagram and in the parts list.

The service instructions are written to facilitate use of a properly functioning synthesizer as a basic test frame for the module. The instrument can be used to support the module, in a convenient bench-service position, and to supply it with power and test signals.

NOTE

First consideration should be given to the use of the wide-spread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty coverage.

Familiarity with the system principles of operation, as discussed in Section 4 of the front portion of this manual, is assumed as a basis for this section. Reference to other module sections should also be made as required.

FA-1.2 PURPOSE.

As noted in paragraph 4.2, the 0- to 100-kc output frequency of a Type 1161 Synthesizer is the result of a heterodyne between a frequency synthesized anywhere in the band from 5.0 to 5.1 Mc/s, and a fixed frequency of 5.0 Mc/s. It is the purpose of the OM-1 Output Mixer module to accept these frequencies from banana plugs in the sandwich deck of the Main Frame, amplify them suitably, and combine them in a balanced mixer. The mixer output, after filtering, is supplied to the input of the main Output Amplifier, P/N 1160-4040, which is a part of the chassis P/N 1160-4060. (Refer to Section BA on the Main Frame, for interconnection circuits.)

FA-1.3 DESCRIPTION.

The Output Mixer module OM-1 plugs onto the rear of the sandwich deck of the Main Frame. Ground connection between the deck and the module case is made by a series of sheet-metal springs, fastened to the deck, that grip the bottom edges of the brass-strip rails which form the outside shell of the module. Two 4-40 screws, which mate with threaded inserts at each end of the rear surface, secure the unit in place.

Circular posts, mounted on the exterior surfaces of the end plates of the unit, serve during disassembly as prying points, by means of which the module can be raised vertically, until the grounding springs and banana plugs are disengaged.

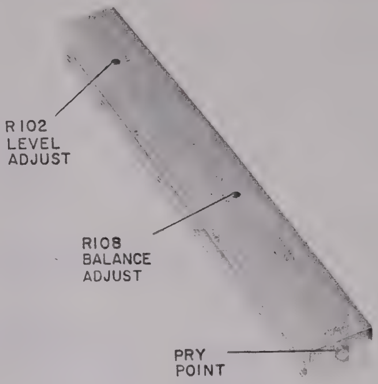


Figure FA-1. Output Mixer module – OM-1.

SECTION FA-2

PRINCIPLES OF OPERATION

FA-2.1 SIGNAL FLOW.

The electrical circuit of the unit is shown in Figure FA-4. A 5.0-Mc reference signal from the AFS crystal oscillator enters at J101A and is fed, via buffer amplifier Q102, to the push-pull side of the output mixer at L104. The 5.0 to 5.1-Mc input (from the train of Digit-Insertion units) enters at J101 and, after amplification by Q101, supplies the other mixer input. The mixer consists of CR101/CR102 and associated components.

The balance control, R108, is used to set the dc component of the output at zero volts. Accurate setting of this control is of importance primarily in connection with dc-coupled output from the synthesizer. (Refer to paragraph 3.4 in the front portion.)

The mixer output, filtered by L102, L103, and C105, C106 and C107 to remove high-frequency components, leaves the module by J202. The low side of the output (at J201) is also grounded at the far end of the coaxial cable which feeds the final Output Amplifier (via AT411 and AT412). Refer to Section BA for details on the Output Amplifier.

Only six banana plugs, in the output-mixer section of the sandwich deck, make electrical connection to the circuits (via jacks J101, J102, J101A, J102A, J201 and J202) of the OM-1 module. The two banana plugs, which conduct 50-Mc and 50/51-Mc outputs from the OMM-1 unit (section FB) when the chassis is used in a Type 1162 Synthesizer, pass through clearance holes in the etched board of this unit and are therefore not activated in a Type 1161 Synthesizer.

SECTION FA-3

SERVICE AND MAINTENANCE

FA-3.1 GENERAL.

If the system trouble-analysis procedures of Section 5 at the front of the manual indicate possible malfunction of the OM-1 unit, the most positive verification of this suspicion is the substitution of another OM-1 module. An OMM-1 module (Section FB) is an equally acceptable substitute.

Since there is but one OM-1 module per instrument, and since service spares may not be available, it will not always be possible to make the substitution. However, selected tests and most alignment procedures can be made in the field.

FA-3.2 TEST EQUIPMENT RECOMMENDED.

Table FA-1 lists the equipment recommended for service of the module. Equivalent equipment may be substituted.

FA-3.3 REMOVAL AND DISASSEMBLY.

FA-3.3.1 REMOVAL FROM MAIN FRAME.

Removal of the module is accomplished as follows:

a. Remove the synthesizer from its case and remove the support bar across the back of the Main Frame chassis.

b. Remove the two 4-40 Phillips-head screws that attach the module to the rear wall of the chassis.

c. Insert a small screwdriver blade through the cutout in the right-hand rear corner of the synthesizer chassis side wall, under the circular post on that end of the module.

d. Insert a second screwdriver blade between the post at the opposite end and the top of the side wall.

e. Pry both ends up simultaneously, until the ground contacts and banana plugs are disconnected.

TABLE FA-1

TEST EQUIPMENT RECOMMENDED

Function	*Type Recommended*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806-A	2% accuracy ac and dc capabilities; 1 – 55-Mc range; 0.2 V sensitivity; probe capacity 2.0 pF maximum.
Oscilloscope	Tektronix Model 543 (with C/A plug-in and P6006 10X passive probe)	20 Mc/s, 0.5 V/cm with 8 pF probe capacitance.
Distortion Analyzer	GR 1932-A	0 – 15 kc/s

FA-3.3.2 REMOVAL OF COVER.

Cover removal is accomplished as follows:

a. Remove the four 4-40 screws in the top of the module, and the two from each side to release the cover.

b. Lift it off and retain the cover and screws.

FA-3.3.3 REASSEMBLY.

Installation of the cover is the reverse of the above. Make sure that the cover, as it is installed, is oriented so that the adjustment-access holes are properly oriented.

FA-3.4 TROUBLE ANALYSIS.

FA-3.4.1 GENERAL (Figure FA-2 and FA-4).

Malfunction within an OM-1 module, as indicated by the system trouble-analysis procedures found in Section 5 at the front of the manual, can be isolated further here. The indications obtained from external connectors and test points on the synthesizer can be used to localize the difficulty to a particular circuit. In the procedures that follow, the top cover must be removed to permit access to interior test and adjustment points (refer to paragraph FA-3.3.2). See Figure FA-2 for locations of interior test points and adjustment controls.

In the performance of these tests the synthesizer Main Frame chassis is used to support the unit, and the other modules are used to power it and to supply loads for its outputs. All DI modules or bridging units should be in place.

With the case removed from the synthesizer and the mixer unit installed (less cover), the instrument can be operated on the test bench. The readings are the same whether or not the cover is in place.

FA-3.4.2 POWER-SUPPLY.

Measure power-supply input voltage at J102 and J102A. This voltage should be +18±0.2 V dc. If not, tests should be made elsewhere in the system to correct this problem (refer to Sections BA, and GA).

TABLE FA-2

DC VOLTAGE LEVELS
(See Figure FA-2)

Transistor	*Emitter*	*Base*	*Collector*
Q101	15.0	14.7	0
Q102	1.0	1.60	17.1

NOTES:
Unit operating in chassis with all inputs; cover removed.
Measured with Type 1806-A direct.
Values are typical; variation of ±10 are to be expected.

FA-3.4.3 SIGNAL CHECKS.

The OM-1 is not operating properly if the output at J202 (normally 0.8 V) is absent, low, or distorted, while both inputs at J101 (5/5.1 Mc/s) and J101A (5.0 Mc/s) are present, at an approximate level of 0.3 V. Set the front-panel LEVEL CONTROL fully CCW for this test.

Absence or low level of output signal may be due to failure of either amplifier, Q101 or Q102; a check of the input signals to the diodes is first indicated. Ac voltages at the mixer inputs are: (VTVM) 1.0 V at L101, terminal 2, and 7 to 8 V at L104, terminals 1 or 3. Low voltage at L101 will lower the mixer output; low voltage at L104 will distort the output signal.

Check dc voltages of the transistors, by use of a probe, on the component side of the etched-circuit board, while the unit is installed in the chassis. Appropriate values are given in Table FA-2.

FA-3.5 ALIGNMENT PROCEDURES.

FA-3.5.1 GENERAL.

If the trouble-analysis procedures of paragraph FA-3.4 indicate marginal performance of a circuit function, or if repairs or replacements have been

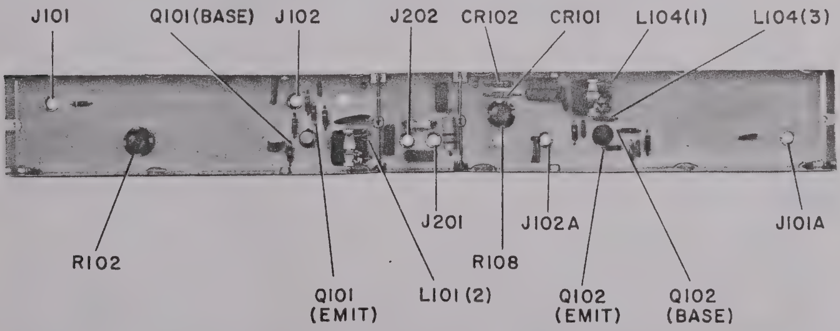


Figure FA-2. Test points and secondary-adjustment controls of Output Mixer module.

made, realignment or adjustments of circuits in the OM-1 unit may be required.

There are two factory-adjusted tuning controls (L101 and L104), a level control (R102), and a mixer-balance control (R108). Normally these should need no adjustment and should not be disturbed in ordinary circumstances. In the adjustment procedures that follow, a JFD #5284 adjustment tool (or equivalent) is recommended. Suggested inputs can conveniently be obtained by plugging the module onto an operating Type 1161 Synthesizer (with dials set for 50 kc/s and LEVEL CONTROL fully CCW).

FA-3.5.2 5.0-Mc INPUT.

With an internal 5-Mc signal of about 0.3 V, rms, applied at J101A, tune L104 for peak output voltage at terminal 1 or 3 of L104. Use the VTVM.

FA-3.5.3 5/5.1 Mc INPUT.

With an internal signal of 0.3 V, rms, to J101, at a frequency of approximately 5.05 Mc/s (selected by front-panel step-digit controls), tune L101 for peak output voltage at terminal 2 of L101, using the VTVM. This is a preliminary adjustment. If an otherwise well-aligned synthesizer is being used as a test jig, it is desirable to obtain equality between the synthesizer output at 1 kc/s and at 99 kc/s by retuning this circuit. These settings are also obtained through use of front-panel step-digit controls.

FA-3.5.4 GAIN.

With L101 and L104 properly tuned, and with signals as specified above applied to J101 and J101A, adjust R102 for 0.8 V, rms, at J202. J202 should be loaded by normal synthesizer circuitry, or by 10 kilohms.

FA-3.5.5 BALANCE.

With alignment complete, and signals applied as specified above, adjust R108 for 0 volt dc at J202.

FA-3.5.6 DISTORTION.

To obtain lowest distortion of the output signal, connect a distortion analyzer to the synthesizer output. Set the synthesizer frequency to 1 kc/s at 1-V output (no 50-ohm load required). Adjust L104 for minimum distortion indication.

NOTE

The cover has no influence on any part of the above alignment procedure.

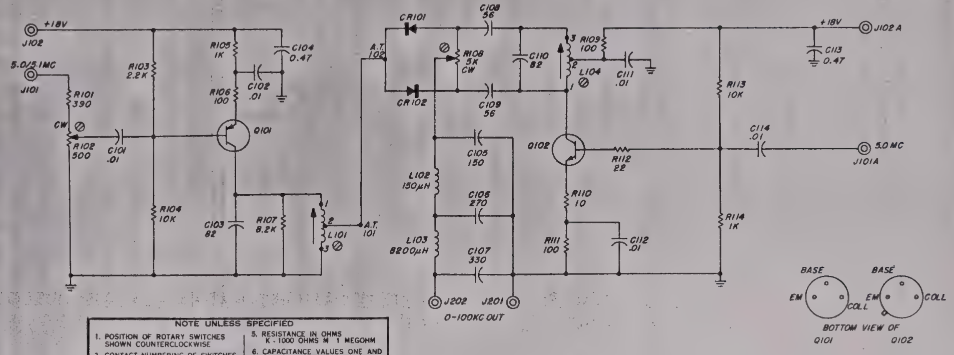
FA-3.6 REPAIRS AND REPLACEMENTS.

If subnormal circuits don't respond to adjustments indicated in the alignment procedures, use the schematic diagram, Figure FA-4, to localize the trouble area; replace defective detail parts. The parts list gives pertinent descriptive information on parts used and reference designators appearing there are the same as those used on schematics and photos. The composite view of the etched-circuit board presented in Figure FA-3 shows the location of all detail parts in the module.

Basing diagrams for the transistor types used are given on the schematic diagrams. The collector lead is identified by a dot on the foil side of the etched-circuit boards.

PARTS LIST

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C101	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C102	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C103	Ceramic, 82 pF ±5% 500 V (N150)	4413-0825
C104	Ceramic, 0.47 µF ±20% 25 V	4400-2054
C105	Mica, 150 pF ±10% 500 V	4700-0440
C106	Mica, 270 pF ±10% 500 V	4700-0527
C107	Mica, 330 pF ±5% 500 V	4700-0516
C108	Mica, 56 pF ±10% 500 V	4700-0316
C109	Mica, 56 pF ±10% 500 V	4700-0316
C110	Ceramic, 82 pF ±5% 500 V (N150)	4413-0825
C111	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C112	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C113	Ceramic, 0.47 µF ±20% 25 V	4400-2054
C114	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
	RESISTORS	
R101	Composition, 390Ω ±5% 1/4 W	6099-1395
R102	Potentiometer, composition, 500Ω ±20%	6040-0300
R103	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R104	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R105	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R106	Composition, 100Ω ±5% 1/4 W	6099-1105
R107	Composition, 8.2 kΩ ±5% 1/4 W	6099-2825
R108	Potentiometer, composition, 5 kΩ ±20%	6040-0600
R109	Composition, 100Ω ±5% 1/4 W	6099-1105
R110	Composition, 10Ω ±5% 1/4 W	6099-0105
R111	Composition, 100Ω ±5% 1/4 W	6099-1105
R112	Composition, 22Ω ±5% 1/4 W	6099-0225
R113	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R114	Composition, 1 kΩ ±5% 1/4 W	6099-2105
	CIRCUIT-BOARD ASSEMBLIES	
—	Assembly, etched-circuit board	1160-2701
	MISCELLANEOUS	
CR101	Diode, semiconductor, type 1N35(S)	6082-1004
CR102	Diode, semiconductor, type 1N35(S)	6082-1004
L101	Inductor, ferrite cup, adjustable	5000-2836
L102	Inductor, choke iron core, 150 µH ±10%	4300-3810
L103	Inductor, choke iron core, 8200 µH ±10%	4300-6391
L104	Inductor, ferrite cup, adjustable	5000-2836
J101	Jack, etched-circuit type	1160-6110
J101A	Jack, etched-circuit type	1160-6110
J102	Jack, etched-circuit type	1160-6110
J102A	Jack, etched-circuit type	1160-6110
J201	Jack, etched-circuit type	1160-6110
J202	Jack, etched-circuit type	1160-6110
Q101	Transistor, type 2N2188	8210-1045
Q102	Transistor, type 2N2218	8210-1028


+18V
J102
5.0/5.1MC
J101
R101
390
CW
R102
500
C101
.01
R103
2.2K
R104
10K
R105
1K
R106
100
C102
.01
C104
0.47
Q101
C103
82
R107
8.2K
L101
A.T.
101
A.T.
102
CR101
CR102
C108
56
C109
56
R108
5K
CW
C110
82
L104
R109
100
C111
.01
L102
150µH
L103
8200µH
C105
150
C106
270
C107
330
J202
J201
0-100KC OUT
Q102
R112
22
R110
10
R111
100
C112
.01
R113
10K
R114
1K
C114
.01
+18V
C113
0.47
J102 A
5.0 MC
J101A
BASE
EM
COLL
BOTTOM VIEW OF
Q101
Q102

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS
   K - 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT - ANCHOR TERMINAL
10. TP - TEST POINT

Figure FA-4. Over-all schematic diagram for Output Mixer OM-1.

NOTE: The number on the foil side is not the part number for the complete assembly. The dot on the foil at the transistor socket indicates the collector lead.

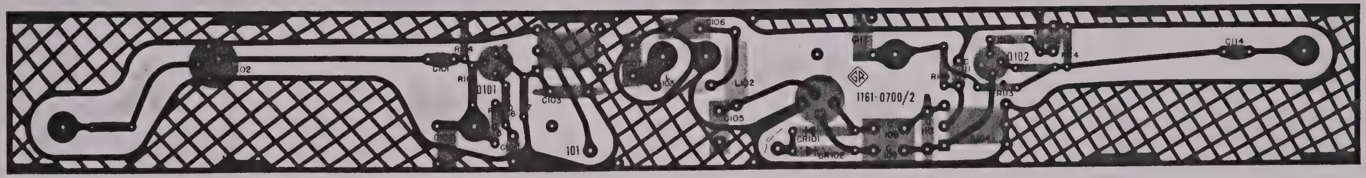

Q102
C101
Q101
C103
101
C106
L102
C105
CR101
CR102
1161-0700/2
R113
C114

Figure FA-3.
Etched circuit board of Output Mixer OM-1 (P/N 1160-2701). Composite view.

SERVICE INSTRUCTIONS

section FB

OUTPUT MULTIPLIER MIXER — OMM-1

P/N 1162-4000
(Used only in Type 1162 Synthesizers)

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Form no. 1160-0110-A ID Number B8 March 1966

GENERAL RADIO COMPANY

West Concord, Massachusetts

SECTION FB-1

INTRODUCTION

FB-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section has been prepared from a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis".

Included in following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension (by experienced service personnel) of the principles of operation. A trouble-analysis procedure that will aid in isolation of defective circuits completes the section.

To facilitate parts identification, reference designators used in the text and on the photographs are the same as those that appear on the complete schematic diagram and in the parts list.

The service instructions are written to facilitate use of a properly functioning synthesizer as a basic test frame for the module. The instrument can be used to support the module, in a convenient bench-service position, and to supply it with power and test signals.

NOTE

First consideration should be given to the use of the widespread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty coverage.

Familiarity with the system principles of operation, as discussed in Section 4 of the front portion of this manual, is assumed as a basis for this section. Reference to other module sections should also be made as required.

FB-1.2 PURPOSE.

As noted in paragraph 4.2, the 0- to 1-Mc output frequency of a Type 1162 Synthesizer is the result of a heterodyne between a frequency synthesized anywhere in the band from 5.0 to 5.1 Mc/s, and a fixed frequency of 5.0 Mc/s, both after X10 multiplication. It is the purpose of the OMM-1 Output Mixer module to accept these initial frequencies from banana plugs in the sandwich deck of the Main Frame, amplify them suitably, multiply them, and combine them in a balanced mixer.

Both the 5.0- to 5.1-Mc output from the train of DI-1 units, and the 5.0-Mc signal from the AFS crystal oscillator, are processed in separate X10 multiplier circuits in the OMM-1, to arrive at mixer frequencies of 50 to 51 Mc/s and 50 Mc/s. The mixer output, after filtering, is supplied to the input of the main Output Amplifier, P/N 1160-4040, which is a part of the chassis P/N 1160-4060. (Refer to Section BA on the Main Frame, for interconnection circuits.)

FB-1.3 DESCRIPTION (Figure FB-1).

The Output Mixer module OMM-1 plugs onto the rear of the sandwich deck of the Main Frame. Ground connection between the deck and the module case is made by a series of sheet-metal springs, fastened to the deck, that grip the bottom edges of the brass-strip rails which form the outside shell of the module. Two 4-40 screws, which mate with threaded inserts at each end of the rear surface, secure the unit in place.

Circular posts, mounted on the exterior surfaces of the end plates of the unit, serve during disassembly as pry points, by means of which the module can be raised vertically, until the grounding springs and banana plugs are disengaged.

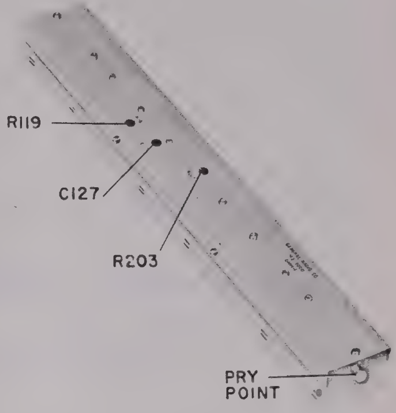


Figure FB-1.
Output Mixer module OMM-1. Note the externally accessible secondary adjustment controls.

SECTION FB-2

PRINCIPLES OF OPERATION

FB-2.1 SIGNAL FLOW.

The OMM-1 contains two essentially identical multiplier boards, one for the 5- to 5.1-Mc variable-frequency input from the train of DI-1 units, and the other for the 5.0-Mc fixed-frequency signal. The frequency-multiplied outputs of these two circuit boards are combined in the output mixer, which occupies the central section of the assembly. The electrical circuitry of these units is shown in Figures FB-2 and FB-6.

An adjustable signal, in the band from 5 to 5.1 Mc/s, enters at J101. It drives Q101, a buffer broadly tuned at 5.05 Mc/s by L101 and C106, which drives a X5 multiplier, Q102. There are three circuits tuned to 25.0/25.5 Mc/s (the coupled pair, L102/L103, and single-tuned L104, at the collector of Q103). Q104 is a doubler, with a double-tuned 50/51-Mc circuit (L106 and L107) that couples it to the double-tuned output amplifier, Q105.

The fixed-frequency signal at 5.0 Mc/s enters the opposite end of the module, at J101A, and is multiplied and amplified in identical circuits. The only difference between the two multiplier boards is in the coupling between the last stages and in the tuning of the tuned circuits.

In the variable-frequency section, T101 is very lightly loaded on its one-turn secondary and consequently needs very small coupling to L109 for proper band-pass characteristics. Since there is some magnetic coupling between the coils, C124 is in a bucking connection to reduce the total coupling.

On the fixed-frequency multiplier board, T101A is heavily loaded by the mixer and consequently requires that C124A be connected in an aiding sense, to develop the desired critical-coupling condition.

The Output Mixer Section, comprised of CR201/CR202 and associated components, feeds the 0—1-Mc output signal through filter inductors L201 and L202 to the output jack, J202. The capacitance of the external coaxial cable, which conducts the output signal of this module to the input of the final Output Amplifier (at the front of the chassis) makes up the balance of this low-pass filter. L202 also furnishes a small amount of high-end peaking to maintain flatness of output.

FB-2.2 INPUTS AND OUTPUTS.

The low side of the output (at J201) is also grounded at the far end of the coaxial cable, which feeds the

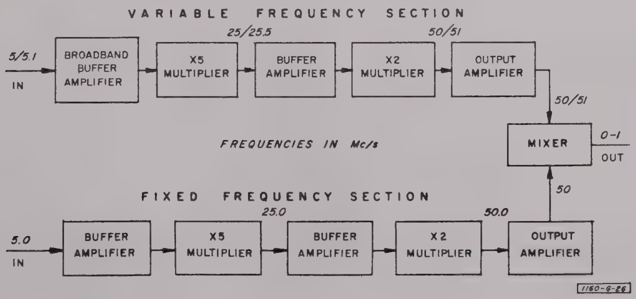

VARIABLE FREQUENCY SECTION
25/25.5
50/51
5/5.1
IN
BROADBAND BUFFER AMPLIFIER
X5 MULTIPLIER
BUFFER AMPLIFIER
X2 MULTIPLIER
OUTPUT AMPLIFIER
50/51
FREQUENCIES IN Mc/s
MIXER
0-1
OUT
50
FIXED FREQUENCY SECTION
25.0
50.0
5.0
IN
BUFFER AMPLIFIER
X5 MULTIPLIER
BUFFER AMPLIFIER
X2 MULTIPLIER
OUTPUT AMPLIFIER
1160-6-26

Figure FB-2.
Block diagram of OMM-1
Output Mixer.

final Output Amplifier (via AT411 and AT412). Refer to Section BA for details on the Output Amplifier.

Eight banana plugs, in the output-mixer station of the sandwich deck, make electrical connection to the circuits (via jacks J101, J101A, J102, J102A, J103, J103A, J201, and J202).

Jacks J103 and J103A connect with banana plugs in the sandwich deck which are wired, through isolating resistors, to subminiature jacks at the rear edge of the deck, to make available 50/51 Mc/s and 50 Mc/s, respectively, at low power levels.

FB-2.3 CONTROLS.

The over-all gain of each multiplier strip can be adjusted by R119 (or R119A), a screwdriver-adjustment potentiometer, which controls the bias on the base of the output stage, Q105 (or Q105A).

Other secondary controls are the screwdriver-adjustable trimmer capacitors, C127 and C127A, placed in the output tank circuits of both multiplier strips. They are useful for touch-up adjustments of the outputs into the mixer circuit.

The balance control, R203, is used to set the dc component of the mixed outputs at zero volts. Accurate setting of this control is of importance primarily in connection with dc-coupled output from the synthesizer. (Refer to paragraph 3.4 in the front portion.)

The frequency alignment of this module is slightly sensitive to the presence of the top cover. As a result, final touch-up adjustments must be made with the cover in place and the unit mounted on the Main Frame.

SECTION FB-3

SERVICE AND MAINTENANCE

FB-3.1 GENERAL.

If the system trouble-analysis procedures of Section 5 at the front of the manual indicate possible malfunction of the OMM-1 unit, the most positive verification of this suspicion is the substitution of another OMM-1 module. An OM-1 module (Section FA) is an acceptable substitute, with the top-frequency limit of 100 kc/s.

Since there is but one OMM-1 module per instrument and since service spares may not be available, it will not always be possible to make the substitution. However, selected tests and alignment procedures can be made in the field.

FB-3.2 TEST EQUIPMENT.

Table FB-1 lists the equipment recommended for service of the module; equivalent equipment may be substituted.

FB-3.3 REMOVAL AND DISASSEMBLY.

FB-3.3.1 REMOVAL FROM MAIN FRAME.

Removal of the module is accomplished as follows:

CAUTION

Turn power off before removal of module.

a. Remove the synthesizer from its case and remove the support bar across the back of the Main Frame chassis.

b. Remove the two 4-40 Phillips-head screws that attach the module to the rear wall of the chassis.

c. Insert a small screwdriver blade through the cutout in the right-hand rear corner of the synthesizer-chassis side wall, under the circular post on the CAD end of the module.

d. Insert a second screwdriver blade between the post at the opposite end and the top of the side wall.

e. Pry both ends up simultaneously, until the ground contacts and banana plugs are disconnected.

TABLE FB-1

TEST EQUIPMENT RECOMMENDED

Function	*Type Recommended*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806-A	2% accuracy; ac and dc capabilities; 1 – 55-Mc range; 0.2 V sensitivity; probe capacity 2.0 pF maximum.
Termination	GR874-W50BL	Standard coaxial, 50 ohms.
Oscilloscope	Tektronix Model 543 (with C/A plug-in and P6006 10x passive probe)	20 Mc/s, 0.5 V/cm with 8 pF probe capacitance.
Distortion Analyzer	GR 1932-A	0 – 15 kc/s

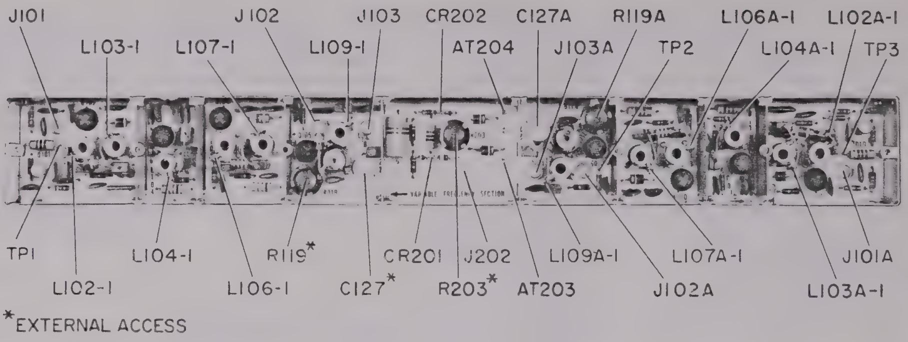


Figure FB-3. Test points and secondary adjustment controls.

FB-3.3.2 REMOVAL OF COVER.

Cover removal is accomplished as follows:

a. Dismount the module from the synthesizer chassis (paragraph FB-3.3.1).

b. Remove the ten 4-40 screws in the top of the module and the two from each side to release the cover.

c. Lift the cover off and retain it and the screws.

FB-3.3.3 REASSEMBLY.

Installation of the cover is the reverse of the above. Make sure that the cover, as it is installed, is oriented so that the adjustment-access holes are over the end away from the CAD side of the unit. Press down firmly to ensure good ground connection.

FB-3.4 TROUBLE ANALYSIS.

FB-3.4.1 GENERAL (Figure FB-3 and FB-6).

Malfunction within an OMM-1 module, as indicated by the system trouble-analysis procedures found in Section 5 at the front of the manual, can be isolated further here. The indications obtained from external connectors and test points on the synthesizer can be used to localize the difficulty to a particular circuit. In the procedures that follow, the top cover must be removed to permit access to interior test and adjustment points (refer to paragraph FB-3.3.2). See Figure FB-3 for locations of interior test points and adjustment controls.

In the performance of these tests, the synthesizer Main Frame chassis is used to support the unit, and the other modules are used to power it and to supply loads for its outputs. All DI modules or bridging units should be in place.

With the case removed from the synthesizer and the mixer unit installed (less cover), the instrument can be operated on the test bench.

FB-3.4.2 POWER-SUPPLY.

Measure power-supply input voltage at J102 and J102A. This voltage should be +18 ±0.2 Vdc. If not, tests should be made elsewhere in the system to correct this problem (refer to Sections BA and GA).

FB-3.4.3 SIGNAL CHECKS.

The OMM-1 is not operating properly if the output at J202 (normally 0.8 V) is absent, low, or distorted, while both inputs at J101 (5/5.1 Mc/s) and J101A (5.0 Mc/s) are present, at an approximate level of 0.3 V, rms. Set the front-panel OUTPUT LEVEL control fully CCW for this test.

Absence or low level of output signal may be due to failure of either multiplier section; a check of the input signals to diodes CR201/CR202 is first indicated. Levels are given in Table FB-2. Low volt-

TABLE FB-2
TROUBLE ANALYSIS

Step	*Circuit*	*Test Point*	*Level (V, rms)*
1	Mixer	J103	1.7 - 2.0
2		AT203	9.0 - 11.0
3		AT204	9.0 - 11.0
4	Variable Frequency Section	L107-1	4.0
5		L104-1	4.0
6		L103-1	2.3
7		TP1 (L101)	1.9
8	Fixed Frequency Section	L107A-1	4.5
9		L104A-1	5.0
10		L103A-1	2.0
11		TP3 (L101A)	1.8

NOTES:
Type 1806-A with ac probe used for all measurements. Reference levels only, subject to fairly wide variations; R119 and R119A permit adjustment of mixer. Determination of the presence or absence of signals rather than their amplitudes will permit localization of trouble.

TABLE FB-3

DC VOLTAGES – OMM-1

Transistor	*Emitter*	*Base*	*Collector*	*Transistor*	*Emitter*	*Base*	*Collector*
Q101	16.4	16.2	0	Q101A	16.4	16.2	0
Q102	1.8	0	16.0	Q102A	1.4	0	16.2
Q103	2.4	3.0	17.0	Q103A	2.4	3.0	16.8
Q104	1.6	1.0	17.0	Q104A	2.0	1.0	16.8
Q105	1.4	1.0	17.0	Q105A	4.0	4.2	15.4

NOTES:
Unit operating with all inputs, installed in chassis, no cover.
Voltages measured with Type 1806-A dc + position.
These are typical readings and they are dependent on rf levels; variations of ±15% are to be expected.
Q105 and Q105A readings are also dependent on R119 and R119A settings.

age at J103 will lower the mixer output; low voltage at AT203 or AT204 will distort the output signal.

If no indication can be obtained at either J103 or AT203 and AT204, proceed sequentially with the probe down the capacatively coupled tuned circuits, from the center toward the input buffers. The test point is always terminal 1 of L109 through L102. The stage immediately following the last tank circuit at which rf can be found, is very likely defective.

Check dc voltages of the transistors, by use of a probe, on the component side of the etched-circuit board, while the unit is installed in the chassis. Appropriate values are given in Table FB-3.

FB-3.5 ALIGNMENT PROCEDURES.

FB-3.5.1 GENERAL (Figure FB-3).

If the trouble-analysis procedures of paragraph FB-3.4 indicate marginal performance of a circuit function, or if repairs or replacements have been made, realignment or adjustments of circuits in the OMM-1 unit may be required.

NOTE

> A complete alignment, particularly of the variable-frequency section, is not possible without a sweep-generator setup and a special cover.

If frequency–insensitive components have been replaced, only a touchup may be required. Repairs in the variable-frequency section will affect the instrument output-frequency response and the output level; repairs in the fixed-frequency section will affect the output-frequency distortion.

FB-3.5.2 VARIABLE-FREQUENCY SECTION.

A JFD No. 5284 adjustment tool is recommended.* Use an operative synthesizer chassis as the test fixture and proceed as follows:

a. Install the OMM-1 unit (with cover) on the deck and apply power.

b. Terminate the synthesizer OUTPUT jack with 50 ohms and set the OUTPUT LEVEL control fully CW.

c. Set the synthesizer output frequency to 190 kc/s and adjust R119 until the MONITOR meter (set to OUTPUT VOLTS) reads full scale, or 2.0 V.

d. Adjust the OUTPUT LEVEL control for a meter reading of one division below full scale.

e. Rotate the 100-kc dial (first) through all positions. If meter readings remain within ±1 division, the output response is within specifications.

f. If not, note the initial position and very carefully adjust C127 to improve response.

When response is satisfactory, readjustment of R119 (for 2.0 V into 50 ohms at lowest point of response) may be indicated.

FB-3.5.3 FIXED-FREQUENCY SECTION.

To permit this operation the OMM-1 unit has to be mounted in an operating synthesizer chassis, without its cover. Use Cambion No. 2230 and JFD No. 5284 alignment tools.** The procedure is as follows:

a. Connect the VTVM (with ac probe) to L104A-1 and peak L102A, L103A.

b. Connect the VTVM to L107A-1 and peak L104A.

c. Connect the VTVM to AT204 and peak L106A, L107A, L109A and C127A. A level of 10 V, rms, should be obtained at this point; readjust R119A if necessary.

d. Measure Q105A emitter voltage at R121A (TP2); it should not exceed 4.0 V.

e. Connect the VTVM to J103A and peak C127A.

If it is desired to check distortion performance, proceed as follows:

a. Set the synthesizer to 1 kc/s; OUTPUT LEVEL to 1 V approximately.

b. Connect (without a 50-ohm load) the Distortion Analyzer to the OUTPUT jack.

c. Use the "100 kΩ, UNBAL" mode to measure distortion.

d. Adjust L106A, L107A, L109 and C127A to minimize distortion.

FB-3.5.4 MIXER-BALANCE ADJUSTMENT.

This balance, primarily provided for zero output in the synthesizer DC OUTPUT COUPLING position, may be adjusted to zero with R203 after the instrument has been set to dc output coupling and the VTVM (dc) has been connected to the output.

---

*NOTE: JFD Electronics Corporation, Brooklyn, New York.

**NOTE: Cambion Coil-Alignment Tool No 2230-1, Cambridge Thermionic Corporation, Cambridge, Massachusetts.

FB-3.6 REPAIRS AND REPLACEMENTS.

If subnormal circuits don't respond to adjustments indicated in the alignment procedures, use the schematic diagram, Figure FB-6, to localize the trouble area; replace defective detail parts. The parts list gives pertinent descriptive information on parts used and reference designators appearing there are the same as those used on schematics and photos. The composite view of the etched-circuit boards, presented in Figures FB-4 and FB-5, show the locations of all detail parts in the module. These figures can also be used to find top-of-board contacts with transistor leads.

Basing diagrams for the transistor types used are given on the schematic diagrams. The collector lead is identified by a dot on the foil side of the etched-circuit boards.

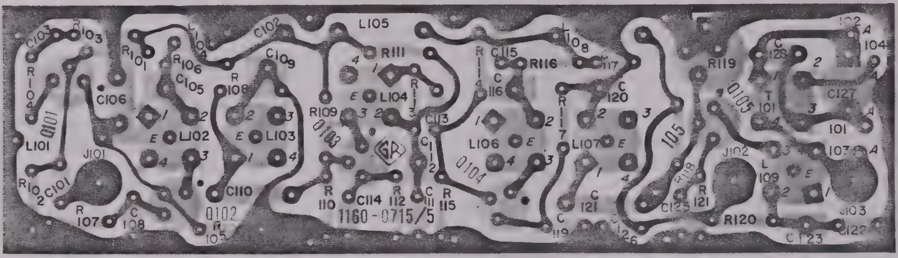

C103
R103
R101
R106
C104
C105
C102
C109
L105
R111
C115
R116
C117
R119
C128
104
R104
C106
Q101
R108
L102
L103
R109
Q103
L104
C113
L106
C116
R117
L107
C120
Q105
105
T101
C127
101
L101
J101
R102
C101
R107
C108
C110
Q102
R105
R110
C114
R112
C111
R115
1160-0715/5
Q104
C121
C119
C126
R118
C125
R121
J102
R120
L109
J103
C123
C122

Figure FB-4. X10 Multiplier-circuit etched-board assembly (P/N 1160-2716 or 1160-2717). Boards identical except for value of C124.

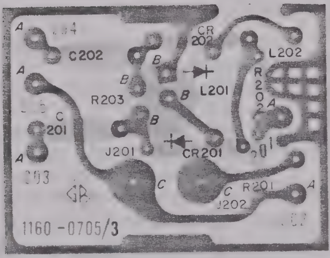

A
C202
CR202
L202
B
R202
L201
R203
C201
J201
CR201
C
R201
J202
1160-0705/3

Figure FB-5. Output mixer-circuit etched-board assembly (P/N 1160-2705).

NOTE: The number appearing on the foil side of the board is not the part number.

PARTS LIST

NOTE

Parts with the suffix A on 100-series reference designators are found in the Fixed Frequency X10 Multiplier. Others are in the Variable Frequency X10 Multiplier. Those in 200-series are on the Output Mixer board.

CAPACITORS

REF NO	DESCRIPTION	PART NO
C101, 101A	Ceramic, 0.01 μF +80-20% 50 V	4404-3100
C102, 102A	Ceramic, 0.47 μF ±20% 25 V	4400-2054
C103, 103A	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C104, 104A	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C105, 105A	Mica, 200 pF ±5% 500 V	4640-0650
C106, 106A	Mica, 75 pF ±5% 500 V	4700-0375
C107, 107A	Ceramic, 1.5 pF ±5% 500 V	4400-0150
C108, 108A	Ceramic, 0.01 pF +80-20% 50 V	4401-3100
C109, 109A	Mica, 200 pF ±5% 500 V	4640-0650
C110, 110A	Ceramic, 10 pF ±10% 500 V	4400-1100
C111, 111A	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C112, 112A	Mica, 200 pF ±5% 500 V	4640-0650
C113, 113A	Ceramic, 16 pF ±5% 500 V (NPO)	4410-0165
C114, 114A	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C115, 115A	Ceramic, 0.001 μF +80-20% 500 V	4404-2109
C116, 116A	Mica, 51 pF ±5% 500 V	4640-0316
C117, 117A	Ceramic, 0.01 μF +80-20%	4401-3100
C118, 118A	Ceramic, 0.33 pF ±5% 500 V	4400-0033
C119, 119A	Ceramic, 0.001 μF +80-20% 500 V	4404-2109
C120, 120A	Mica, 51 pF ±5% 500 V	4640-0316
C121, 121A	Ceramic, 6.8 pF ±10% 500 V	4400-0800
C122, 122A	Ceramic, 0.001 μF +80-20% 500 V	4404-2109
C123, 123A	Mica, 51 pF ±5% 500 V	4640-0316
C124	Ceramic, 1.0 pF ±5% 500 V	4400-0101
C124A	Ceramic, 1.5 pF ±5% 500 V	4400-0150
C125, 125A	Ceramic, 0.001 μF +80-20% 500 V	4404-2109
C126, 126A	Ceramic, 0.01 μF +80-20% 50 V	4401-3100
C127, 127A	Trimmer, 5.5-18 pF 350 V	4910-2044
C128, 128A	Ceramic, 10 pF ±5% 500 V (N30)	4411-0105
C201	Ceramic, 5.6 pF ±10% 500 V	4400-0569
C202	Ceramic, 5.6 pF ±10% 500 V	4400-0569

INDUCTORS

REF NO	DESCRIPTION	PART NO
L101, 101A	Choke, rf, 10 μH ±10%	4300-2200
L102, 102A	Adjustable	1160-2400
L103, 103A	Adjustable, ceramic	1160-2410
L104, 104A	Adjustable, ceramic	1160-2400
L105, 105A	Choke, rf, 22 μH ±10%	4300-2600
L106, 106A	Adjustable, ceramic	1160-2400
L107, 107A	Adjustable, ceramic	1160-2410
L108, 108A	Choke, rf, 22 μH ±10%	4300-2600
L109, 109A	Adjustable, ceramic	1160-2400
L201	Choke, rf, 10 μH ±10%	4300-2200
L202	Choke, rf, 560 μH ±10%	4300-4900

RESISTORS

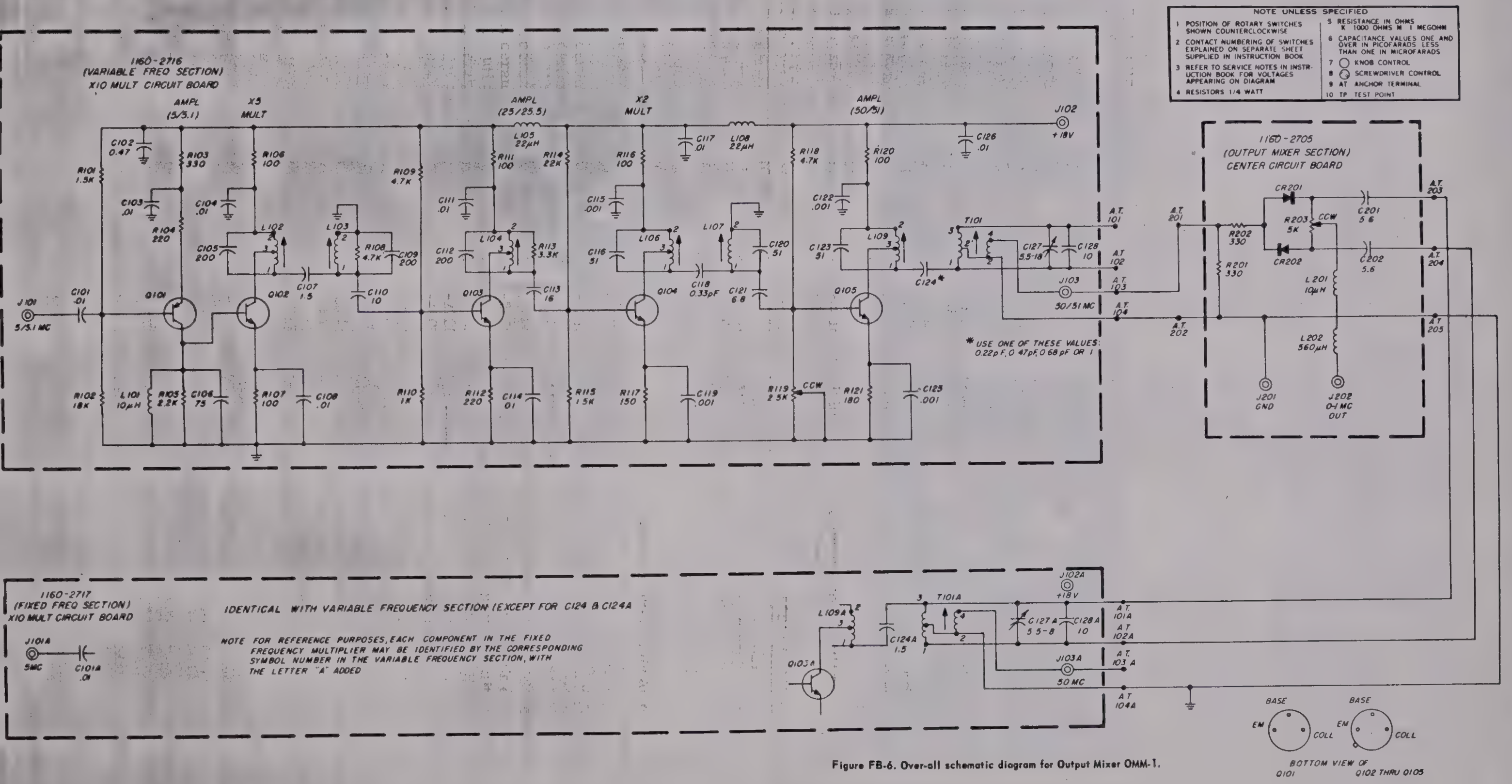
REF NO	DESCRIPTION	PART NO
R101, 101A	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R102, 102A	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R103, 103A	Composition, 330 Ω ±5% 1/4 W	6099-1335
R104, 104A	Composition, 220 Ω ±5% 1/4 W	6099-1225
R105, 105A	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R106, 106A	Composition, 100 Ω ±5% 1/4 W	6099-1105
R107, 107A	Composition, 100 Ω ±5% 1/4 W	6099-1105
R108, 108A	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R109, 109A	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R110, 110A	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R111, 111A	Composition, 100 Ω ±5% 1/4 W	6099-1105
R112, 112A	Composition, 220 Ω ±5% 1/4 W	6099-1225
R113, 113A	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R114, 114A	Composition, 22 kΩ ±5% 1/4 W	6099-3225
R115, 115A	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R116, 116A	Composition, 100 Ω ±5% 1/4 W	6099-1105
R117, 117A	Composition, 150 Ω ±5% 1/4 W	6099-1115
R118, 118A	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R119, 119A	Potentiometer, composition 2.5 kΩ 20%	6040-0500
R120, 120A	Composition, 100 Ω ±5% 1/4 W	6099-1105
R121, 121A	Composition, 180 Ω ±5% 1/4 W	6099-1185
R201	Composition, 330 Ω ±5% 1/4 W	6099-1335
R202	Composition, 330 Ω ±5% 1/4 W	6099-1335
R203	Potentiometer, composition 5 kΩ 20%	6040-0600

MISCELLANEOUS

REF NO	DESCRIPTION	PART NO
CR201, 202	Diode, type 1N35(S)	6082-1004
J101, 101A	Jack, etched-circuit connector	1160-6110
J102, 102A	Jack, etched-circuit connector	1160-6110
J103, 103A	Jack, etched-circuit connector	1160-6110
J201	Jack, etched-circuit connector	1160-6110
J202	Jack, etched-circuit connector	1160-6110
T101, 101A	Transformer, adjustable	1160-2390
Q101, 101A	Transistor, type 2N2188	8210-1045
Q102, 102A	Transistor, type 2N2218	8210-1028
Q103, 103A	Transistor, type 2N2218	8210-1028
Q104, 104A	Transistor, type 2N2218	8210-1028
Q105, 105A	Transistor, type 2N2218	8210-1028

CIRCUIT-BOARD ASSEMBLIES

REF NO	DESCRIPTION	PART NO
—	Output Mixer Circuit etched-board	1160-2705
—	X10 Multiplier Circuit etched-board (Variable Frequency)	1160-2716
—	X10 Multiplier Circuit etched-board (Fixed Frequency)	1160-2717


1160-2716
(VARIABLE FREQ SECTION)
X10 MULT CIRCUIT BOARD
AMPL
(5/5.1)
X5
MULT
AMPL
(25/25.5)
X2
MULT
AMPL
(50/51)
J101
5/5.1 MC
C101
.01
R101
1.5K
C102
0.47
R103
330
C103
.01
R104
220
Q101
R102
18K
L101
10μH
R105
2.2K
C106
75
R106
100
C104
.01
L102
C105
200
Q102
R107
100
C108
.01
C107
1.5
L103
R108
4.7K
C109
200
C110
10
R109
4.7K
R110
1K
L105
22μH
R111
100
R114
22K
C111
.01
L104
C112
200
R113
3.3K
C113
16
Q103
R112
220
C114
.01
R115
1.5K
R116
100
C115
.001
L106
C116
51
Q104
R117
150
C119
.001
C117
.01
L108
22μH
L107
C120
51
C118
0.33pF
C121
6.8
R118
4.7K
R119
2.5K
CCW
R120
100
C122
.001
L109
C123
51
Q105
R121
180
C125
.001
C124*
C126
.01
J102
+18V
T101
C127
5.5-18
C128
10
J103
50/51 MC
A.T.
101
A.T.
102
A.T.
103
A.T.
104
1
2
3
4
1160-2705
(OUTPUT MIXER SECTION)
CENTER CIRCUIT BOARD
A.T.
201
A.T.
202
R202
330
R201
330
CR201
CR202
R203
5K
CCW
C201
5.6
C202
5.6
L201
10μH
L202
560μH
J201
GND
J202
0-1 MC
OUT
A.T.
203
A.T.
204
A.T.
205
1160-2717
(FIXED FREQ SECTION)
X10 MULT CIRCUIT BOARD
J101A
5MC
C101A
.01
Q103A
L109A
C124A
1.5
T101A
C127A
5.5-8
C128A
10
J102A
+18V
J103A
50 MC
A.T.
101A
A.T.
102A
A.T.
103 A
A.T.
104A
BASE
EM
COLL
BOTTOM VIEW OF
Q101
Q102 THRU Q105

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS
   K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS LESS THAN ONE IN MICROFARADS
7. ○ KNOB CONTROL
8. ◷ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

* USE ONE OF THESE VALUES: 0.22pF, 0.47pF, 0.68 pF OR 1

IDENTICAL WITH VARIABLE FREQUENCY SECTION (EXCEPT FOR C124 & C124A

NOTE FOR REFERENCE PURPOSES, EACH COMPONENT IN THE FIXED FREQUENCY MULTIPLIER MAY BE IDENTIFIED BY THE CORRESPONDING SYMBOL NUMBER IN THE VARIABLE FREQUENCY SECTION, WITH THE LETTER "A" ADDED

Figure FB-6. Over-all schematic diagram for Output Mixer OMM-1.

SERVICE INSTRUCTIONS

section FC

OUTPUT MULTIPLIER MIXER_OMM-2

P/N 1163-4010
(Used only in Type 1163 Synthesizers)

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Form No. 1163-4010-A ID Number B207 March 1966

GENERAL RADIO COMPANY
West Concord, Massachusetts

SECTION FC-1

INTRODUCTION

FC-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section has been prepared from a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis".

Included in the following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension, by experienced service personnel, of the principles of operation. A trouble-analysis procedure that will aid in isolation of defective circuits completes the section.

To facilitate parts identification, reference designators used in the text and on the photographs are the same as those that appear on the complete schematic diagram and in the parts list.

The service instructions are written to facilitate use of a properly functioning synthesizer as a basic test frame for the module. The instrument can be used to support the module, in a convenient bench-service position, and to supply it with power and test signals.

NOTE

> First consideration should be given to the use of the widespread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty coverage.

Familiarity with the system principles of operation, as discussed in Section 4 of the front portion of this manual, is assumed as a basis for this section. Reference to other module sections should also be made as required.

FC-1.2 PURPOSE.

As noted in paragraph 4.7, the 30-c to 12-Mc output frequency of a Type 1163 Synthesizer is the result of a heterodyne between a frequency synthesized between 50 to 51 Mc/s and a frequency between 50 and 39 Mc/s.

The purpose of the OMM-2 unit is to accept from the DI-1 train a frequency adjustable between 5.0 and 5.1 Mc/s, multiply it by 10 (to 50 to 51 Mc/s), subtract from it the 39 to 50 Mc/s (1-Mc steps) from the DI-4, amplify the result, and feed it to the Output Amplifier (P/N 1163-4040) through the sandwich-deck wiring. Refer to Section BB (on the Main Frame) for interconnecting circuits.

FC-1.3 DESCRIPTION (Figure FC-1).

The Output Mixer module OMM-2 plugs onto the rear of the sandwich deck of the Main Frame. Ground connection between the deck and the module case is made by a series of sheet-metal springs, fastened to the deck, that grip the bottom edges of the brass-strip rails which form the outside shell of the module. Two 4-40 screws, which mate with threaded inserts at each end of the rear surface, secure the unit in place.

Circular posts mounted on the exterior surfaces of the end plates of the unit serve during disassembly as pry points, by means of which the module can be raised vertically, until the grounding springs and banana plugs are disengaged.

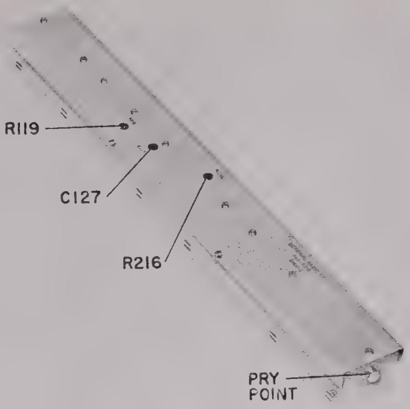


Figure FC-1. Output Multiplier Mixer module OMM-2, showing location of secondary controls.

SECTION FC-2

PRINCIPLES OF OPERATION

FC-2.1 SIGNAL FLOW.

The OMM-2 unit contains two etched-circuit boards. One is the X10 multiplier, which accepts the 5 to 5.1-Mc adjustable frequency from the DI-1 units. The other contains an amplitude leveler for the multiplied 50 to 51-Mc signal, the input and isolation amplifier for the signal from the DI-4 (from 39 to 50 Mc/s), the output mixer, low-pass filter, and output preamplifier. A block diagram of the unit appears in Figure FC-2. The complete electrical circuit is shown in Figure FC-6.

An adjustable signal, in the band from 5 to 5.1 Mc/s, enters at J101. It drives Q101, a buffer broadly tuned at 5.05 Mc/s by L101 and C106, which drives a X5 multiplier, Q102. There are three circuits tuned to 25.0/25.5 Mc/s (the coupled pair, L102/L103, and single-tuned L104, at the collector of Q103). Q104 is a doubler, with a double-tuned 50/51-Mc circuit (L106 and L107) that couples it to the double-tuned output amplifier, Q105.

In the output circuit of Q105, T101 is very lightly loaded on its one-turn secondary. Consequently it needs very small coupling of L109 for proper band-pass characteristics. Since there is some magnetic coupling between the coils, C124 is in a bucking connection to reduce the total coupling.

The 50 to 51-Mc leveler circuit includes the components associated with Q203 and CR203. CR203 rectifies the signal produced at the output of the X10 multiplier circuit, producing a bias at Q203 that is dependent on the level of the 50 to 51-Mc signal. Q203, a dc amplifier, uses the voltage produced by the ALC detector to control the bias of Q105 and thereby control the output signal (at 50-51 Mc/s) fed to R216. R216, in turn, is a potentiometer control that can be adjusted to give the desired drive to the output mixer.

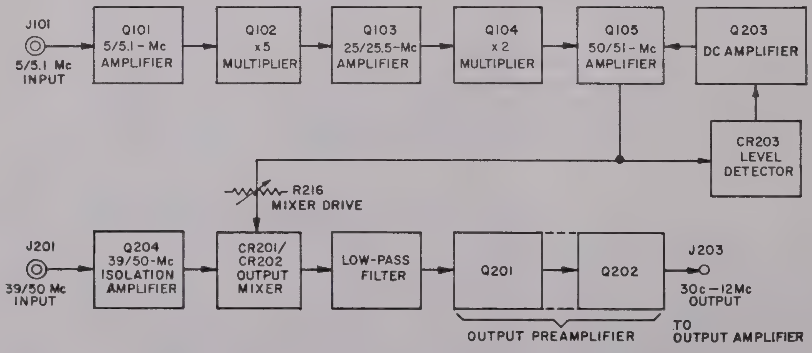

J101
5/5.1 Mc INPUT
Q101 5/5.1 - Mc AMPLIFIER
Q102 x5 MULTIPLIER
Q103 25/25.5-Mc AMPLIFIER
Q104 x 2 MULTIPLIER
Q105 50/51 - Mc AMPLIFIER
Q203 DC AMPLIFIER
CR203 LEVEL DETECTOR
R216 MIXER DRIVE
J201
39/50 Mc INPUT
Q204 39/50-Mc ISOLATION AMPLIFIER
CR201/ CR202 OUTPUT MIXER
LOW-PASS FILTER
Q201
Q202
OUTPUT PREAMPLIFIER
J203
30c—12Mc OUTPUT
TO OUTPUT AMPLIFIER

Figure FC-2. Block diagram of Output Multiplier-Mixer OMM-2.

The output mixer, comprising T201 and CR201/CR202, is driven by Q204 and the 50 to 51-Mc signal described above. Q204 is an isolation amplifier driven by the DI-4 signal (39-50 Mc/s) that prevents signals in the mixer from being fed back to the DI-4. The signal levels fed to the mixer differ in voltage level by about 10:1, the 39 to 50 Mc/s from Q204 being the higher signal. The output level from the mixer is thus controlled by the leveled 50 to 51-Mc input from T202.

The mixer load comprises R201 and the low-pass filter. The low-pass filter is an elliptic-function filter designed to have 0.1-dB ripple in the 0 to 12-Mc passband of the Type 1163 Synthesizer and fast roll-off to reject the 39 to 51-Mc signals also coming from the mixer. The filter has a minimum rejection of 65 dB, beyond 30 Mc/s. The elements in the filter are either fixed precision, or factory preadjusted, and cannot be adjusted in the field.

The signal at the filter, which is about 10 mV, drives the two-stage, wide-band preamplifier Q201 and Q202. Q201 is a common-emitter, emitter-compensated stage loaded by a common-emitter, shunt-feedback stage, Q202. The load resistor for Q202 is R401, the 250-ohm OUTPUT LEVEL control on the front panel of the Main Frame (refer to Section BB).

The high-frequency compensation for Q201 comprises R206 and C208. The high-frequency compensation for Q202 consists of R208 and L203. The low frequency cutoff is determined by C207, C210, and the associated impedances, but C209 and R208 increase the gain of Q202 at low audio frequencies. The actual shape of the response curve depends on the tolerances of these components, but a typical unit is nearly flat to 10 c/s. The low-frequency output response (of the Type 1163) is therefore largely determined by the Output Amplifier, P/N 1163-4040 (Section BB).

FC-2.2 INPUT AND OUTPUT CONNECTIONS.

Input and output connections to the OMM-2 unit are made through seven banana jacks and one ground lug.

The 5/5.1-Mc input from the DI-1 units comes into J101. The 39/50-Mc signal from the DI-4 arrives at J201, where a ground pin and spring (on the chassis) are used to keep signal paths short.

The +18 V dc arrives at two jacks, one for the multiplier, J102, and one for the preamplifier circuits, J202.

The output is carried to the front-panel OUTPUT LEVEL control via J203 and associated ground return, J204; refer to Section BB for details on this wiring. The impedance of OUTPUT LEVEL control R401 is sufficiently low so the cable capacitance can be ignored.

J103 connects with a banana plug in the sandwich deck, which is wired through an isolating resistor to subminiature jack J154 at the rear edge of the deck, to make available 50/51 Mc/s, at a low power level.

FC-2.3 CONTROLS.

There is provision for access through the top cover of the module for three secondary controls, C127, R216 and R119. These controls should rarely need adjustment.

C127 is a screwdriver-adjustable trimmer capacitor placed in the output tank circuit of the multiplier strip. It is useful for touch-up adjustments of the multiplier output to the mixer circuit.

The setting of R216 determines the drive to the preamplifier and the over-all synthesizer output. It should be set so that the synthesizer will deliver full rated output (2.0 V open circuit) at all frequencies.

R119 is a gain control in the X10 multiplier circuit, useful only when no leveling circuit is available, i.e. when this board is installed as part of the OMM-1 unit (Section FB). In the OMM-2 module, this control is set fully clockwise.

The frequency alignment of this module is slightly sensitive to the presence of the top cover. As a result, final touch-up adjustments must be made with the cover in place and the unit mounted on the Main Frame.

SECTION FC-3

SERVICE AND MAINTENANCE

FC-3.1 GENERAL.

If the system trouble-analysis procedures of Section 5 at the front of the manual indicate possible malfunction of the OMM-2 unit, the most positive verification of this suspicion is the substitution of another OMM-2 module.

Since there is but one OMM-2 module per instrument and since service spares may not be available, it will not always be possible to make the substitution. However, selected tests, and alignment procedures can be made in the field.

FC-3.2 TEST EQUIPMENT.

Table FC-1 lists the equipment recommended for service of the module; equivalent equipment may be substituted.

FC-3.3 REMOVAL AND DISASSEMBLY.

FC-3.3.1 REMOVAL FROM MAIN FRAME.

Removal of the module is accomplished as follows:

CAUTION

Turn power off before removal of module.

a. Remove the synthesizer from its case and remove the support bar across the back of the Main Frame chassis.

b. Remove the two 4-40 Phillips-head screws that attach the module to the rear wall of the chassis.

c. Insert a small screwdriver blade through the cutout in the right-hand rear corner of the synthesizer-chassis side wall, under the circular post on the CAD end of the module.

d. Insert a second screwdriver blade between the post at the opposite end and the top of the side wall.

e. Pry both ends up simultaneously, until the ground contacts and banana plugs are disconnected.

FC-3.3.2 REMOVAL OF COVER.

Cover removal is accomplished as follows:

a. Dismount the module from the synthesizer chassis (paragraph FC-3.3.1).

TABLE FC-1

TEST EQUIPMENT RECOMMENDED

Function	*Type*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806-A	2% accuracy; ac and dc capabilities; 1 to 55-Mc range; 0.2 V sensitivity; probe capacitance 2.0 pF maximum.
Oscilloscope	Tektronix Model 543 (with C/A plug-in and P6006 10x passive probe).	20 Mc/s, 0.5 V/cm, with 8 pF probe capacitance.
Standard Sweep Frequency Generator	GR 1025-A	0.5% calibration accuracy.

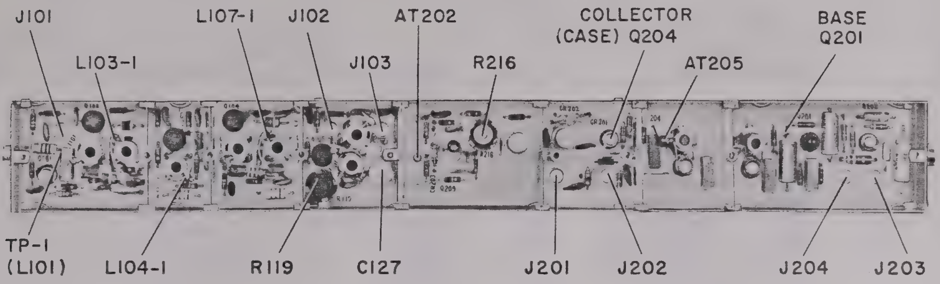


Figure FC-3. Interior view of OMM-2 module showing test points and secondary adjustment controls.

b. Remove the nine 4-40 screws in the top of the module and the two from each side to release the cover.

c. Lift the cover off and retain it and the screws.

FC-3.3.3 REASSEMBLY AND INSTALLATION.

Installation of the cover is the reverse of the above. When reinstalling the module on the chassis be sure that its bottom rail engages the grounding springs in such a way that the springs are not damaged. Press down until the module is seated firmly in place.

FC-3.4 TROUBLE ANALYSIS.

FC-3.4.1 GENERAL (Figures FC-3 and FC-6).

Malfunction within an OMM-2 module, as indicated by the system trouble-analysis procedures found in Section 5 at the front of the manual, can be isolated further here. The indications obtained from external connectors and test points on the synthesizer can be used to localize the difficulty to a particular circuit. In the procedures that follow, the top cover must be removed to permit access to interior test and adjustment points (refer to paragraph FC-3.3.2). See Figure FC-3 for locations of interior test points and adjustment controls.

In the performance of these tests, the synthesizer Main Frame chassis is used to support the unit, and the other modules are used to power it and to supply loads for its outputs. All DI modules or bridging units should be in place.

With the case removed from the synthesizer and the mixer unit installed (less cover), the instrument can be operated on the test bench.

FC-3.4.2 POWER-SUPPLY.

Measure power-supply input voltage at J102 and J202. This voltage should be +18 ±0.2 Vdc. If not, tests should be made elsewhere in the system to correct this defect (refer to Sections BB and GA).

FC-3.4.3 SIGNAL CHECKS.

The OMM-2 is not operating properly if the output at J203 (normally 0.8 V) is absent, low, or distorted, while both inputs at J101 (5/5.1 Mc/s) and J201 (39/50 Mc/s) are present, at an approximate level of 0.3 V, rms. Set the front-panel OUTPUT LEVEL control fully CCW for this test.

Absence or low level of output signal may be due to failure of the multiplier section, or isolation amplifier, Q204. A check of voltages is given in Table FC-2. Low voltage at J103 will lower the mixer output; low voltage at the collector of Q204 will distort the output signal.

If no indication can be obtained at either J103 or AT202, proceed sequentially with the probe down the capacatively coupled tuned circuits, from the center toward the input buffers. The test point is always terminal 1 of L109, L107, L106, L104, L103 and L102. The stage immediately following the last tank circuit at which rf can be found is very likely defective.

If signals are present at both sides of the mixer, measure the output of the mixer at the output of the low-pass filter with a sensitive VTVM at L202 pin 2, to check operation of the mixer. Observations at test points in this end of the module should isolate trouble to a defective stage. Table FC-2 gives values for the signals at various points.

At any stage giving abnormal indications, in the course of preceding procedures, check the dc voltages of the transistors, by use of a VTVM (with probe), on the component side of the etched-circuit board, while

TABLE FC-2

TROUBLE-ANALYSIS (Figure FC-3)

Step	*Section*	*Test Point*	*Indication (V, rms)*
1	Mixer-Preamp	J203	0.7-1.0
2		Base, Q201	.008-.010
3		Coll. (case) Q204	2.0-3.0
4		J103	0.8-1.0
5	X10 Multiplier	L107-1	4.0
6		L104-1	4.0
7		L103-1	2.3
8		TP1 (L101)	1.9

NOTES:

Type 1806-A with ac probe used for all measurements but step 2.

Reference levels only; subject to fairly wide variations. Determination of the presence or absence of signals rather than their amplitudes will permit localization of trouble.

TABLE FC-3
DC VOLTAGE LEVELS
(Figure FC-3)

Transistor	*Collector*	*Base*	*Emitter*
Q101	0	16.2	16.4
Q102	16.0	0	1.9
Q103	17.1	3.0	2.4
Q104	17.1	1.0	1.6
Q105	17.8	0.4-1.5*	1.3
Q201	7.9	0.85	.076
Q202	3.6	7.9	8.5
Q203	0.4-1.5*	0.5	.02
Q204	0	12.8	13.5

NOTES:

Unit operating with all inputs, installed in chassis, no cover.
Voltages measure with Type 1806-A dc + position.
These are typical readings and they are dependent on rf levels; variations of ±15% are to be expected.
*Dependent on gain in ALC circuit.

the unit is installed in the chassis. Appropriate values are given in Table FC-3.

FC-3.5 ADJUSTMENT PROCEDURES.

FC-3.5.1 GENERAL (Figure FC-3).

If the trouble-analysis procedures of paragraph FC-3.4 indicate marginal performance of a circuit function, or if repairs or replacements have been made, adjustments of circuits in the OMM-2 unit may be required.

NOTE

> A complete alignment of the X10 multiplier section is not possible without a sweep-generator setup and a special cover.

If frequency-insensitive components have been replaced, no alignment will be required. Repairs in the X10 multiplier section can affect the instrument output-frequency response and the output level; repairs in the remainder of the module may affect the level and distortion of the output-frequency.

FC-3.5.2 X10 MULTIPLIER SECTION CHECKS.

To test the X10 multiplier and ALC circuit section, after replacement of frequency-insensitive components, proceed as follows:

a. Set the synthesizer to 5.000000-Mc output frequency and OUTPUT LEVEL to 2.0 V.

b. Set the MONITOR switch to OUTPUT VOLTS.

c. Rotate the dial of the X100 KC DI-1 through all 10 positions (5.0 to 5.9 Mc/s) and observe the MONITOR meter.

d. If the output-level indication does not vary more than a fraction of a division (1 division ≈ 0.2V), it can be assumed that the X10 multiplier and leveler circuits are operating properly.

e. If larger variations are observed, realignment at the factory is required.

FC-3.5.3 MIXER PREAMP TESTS AND ALIGNMENT.

NOTE

> The following information assumes that the X10 multiplier circuit and ALC control are in proper operating condition (paragraph 3.5.2).

The only adjustment in this section is the mixer drive, R216. This control is adjusted to give 2 volts open-circuit at the synthesizer OUTPUT jack, when the OUTPUT LEVEL control is full CW. If the voltage at J203, resulting from this adjustment, is greater than 0.9 V, rms, at the synthesizer output frequency, an additional check should be made to see that no malfunction exists in the Output Amplifier (refer to Section BB).

If the output characteristic of the synthesizer is insufficiently flat, and if the voltage at AT202 is within limits over the DI-1 adjustment range (paragraph 3.5.2), interconnections at AT204 and AT205 may be opened and a response check made of the low-pass filter and preamplifier section only. A drive signal of 9-11 mV should result in an output of 0.8 V at J203; use the sweep-frequency generator. With a constant signal level at AT205, the level at J203 should not vary more than ±0.5 dB from 50 c/s to 12 Mc/s. The OUTPUT LEVEL control on the front panel of the synthesizer should be fully CCW for this measurement.

FC-3.6 REPAIRS AND REPLACEMENTS.

If subnormal circuits don't respond to adjustments indicated in the alignment procedures, use the schematic diagram, Figure FC-6, to localize the trouble area; replace defective detail parts. The parts list gives pertinent descriptive information on parts used and reference designators appearing there are the same as those used on schematics and photos. The composite view of the etched-circuit board presented in Figures FC-4 and FC-5 show the locations of all detail parts in the module. These figures can also be used to find top-of-board contacts with transistor leads.

Basing diagrams for the transistor types used are given on the schematic diagrams. The collector lead is identified by a dot on the foil side of the etched-circuit boards.

PARTS LIST

CAPACITORS

REF NO	DESCRIPTION	PART NO
C101	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C102	Ceramic, 0.47 µF ±20% 25 V	4400-2054
C103	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C104	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C105	Mica, 200 pF ±5% 500 V	4640-0650
C106	Mica, 75 pF ±5% 500 V	4700-0375
C107	Ceramic, 1.5 pF ±5% 500 V	4400-0150
C108	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C109	Mica, 200 pF ±5% 500 V	4640-0650
C110	Ceramic, 10 pF ±5% 500 V	4400-1100
C111	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C112	Mica, 200 pF ±5% 500 V	4640-0650
C113	Ceramic, 16 pF ±5% 500 V (NPO)	4410-0165
C114	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C115	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C116	Mica, 51 pF ±5% 500 V	4640-0316
C117	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C118	Ceramic, 0.33 pF ±5% 500 V	4400-0033
C119	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C120	Mica, 51 pF ±5% 500 V	4640-0316
C121	Ceramic, 6.8 pF ±10% 500 V	4400-0800
C122	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C123	Mica, 51 pF ±5% 500 V	4640-0316
C124	Ceramic, 1.0 pF ±5% 500 V	4400-0101
C125	Ceramic, 0.001 µF +80-20% 500 V	4404-2109
C126	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C127	Trimmer, 5.5 to 18 pF 350V	4910-2044
C128	Ceramic, 10 pF ±5% 500 V (N30)	4411-0105
C201	Mica, 121 pF ±1% 500 V	4710-0031
C202	Trimmer, 0.8 to 8.5 pF	4910-1100
C203	Ceramic, 10 pF ±5% 500 V	4411-0105
C204	Mica, 221 pF ±1% 500 V	4710-0400
C205	Trimmer, 0.8 to 8.5 pF	4910-1100
C206	Mica, 140 pF ±1% 500 V	4710-0140
C207	Electrolytic, 180 µF ±20% 6 V	4450-5617
C208	Mica, 1200 pF ±5% 100 V	4700-0685
C209	Electrolytic, 4.7 µF ±20% 10 V	4450-4700
C210	Electrolytic, 120 µF ±20% 10 V	4450-5616
C211	Electrolytic, 47 µF ±20% 20 V	4450-5614
C212	Ceramic, 10 pF ±10% 500 V (N30)	4411-0105
C213	Ceramic, 0.001 µF ±10% 500 V	4405-2108
C214	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C215	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C216	Ceramic, 0.001 µF ±10% 500 V	4405-2108
C217	Ceramic, 0.001 µF ±10% 500 V	4405-2108
C218	Ceramic, 0.001 µF ±10% 500 V	4405-2108
C219	Ceramic, 150 pF ±5% 500 V	4404-1155

INDUCTORS

REF NO	DESCRIPTION	PART NO
L101	Choke, rf, 10 µH ±10%	4300-2200
L102	Adjustable	1160-2400
L103	Adjustable	1160-2410
L104	Adjustable	1160-2400
L105	Adjustable, 22 µH ±10%	4300-2600
L106	Adjustable	1160-2400
L107	Adjustable	1160-2410
L108	Adjustable, 22 µH ±10%	4300-2600
L109	Adjustable	1160-2400
L201	Adjustable	1163-2240
L202	Adjustable	1163-2231
L203	Adjustable, 3.9 µH ±10%	4300-1500

RESISTORS

REF NO	DESCRIPTION	PART NO
R101	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R102	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R103	Composition, 330 Ω ±5% 1/4 W	6099-1335

RESISTORS(Cont)

REF NO	DESCRIPTION	PART NO
R104	Composition, 220 Ω ±5% 1/4 W	6099-1225
R105	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R106	Composition, 100 Ω ±5% 1/4 W	6099-1105
R107	Composition, 100 Ω ±5% 1/4 W	6099-1105
R108	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R109	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475
R110	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R111	Composition, 100 Ω ±5% 1/4 W	6099-1105
R112	Composition, 220 Ω ±5% 1/4 W	6099-1225
R113	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R114	Composition, 22 kΩ ±5% 1/4 W	6099-3225
R115	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R116	Composition, 100 Ω ±5% 1/4 W	6099-1105
R117	Composition, 150 Ω ±5% 1/4 W	6099-1155
R118	Composition, 100 kΩ ±5% 1/4 W	6099-4105
R119	Potentiometer, composition 25 kΩ ±20%	6040-0800
R120	Composition, 100 Ω ±5% 1/4 W	6090-1105
R121	Composition, 330 Ω ±5% 1/4 W	6090-1335
R201	Composition, 200 Ω ±5% 1/4 W	6099-1205
R202	Composition, 100 Ω ±5% 1/4 W	6099-1105
R203	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R204	Composition, 8.2 kΩ ±5% 1/4 W	6099-2825
R205	Composition, 1 kΩ ±5% 1/4 W	6099-2105
R206	Composition, 18 Ω ±5% 1/4 W	6099-0185
R207	Composition, 390 Ω ±5% 1/2 W	6100-1395
R208	Composition, 3.9 kΩ ±5% 1/4 W	6099-2395
R210	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R211	Composition, 100 Ω ±5% 1/4 W	6099-1105
R212	Composition, 10 kΩ ±5% 1/4 W	6099-3105
R213	Composition, 680 Ω ±5% 1/4 W	6099-1685
R214	Composition, 100 Ω ±5% 1/4 W	6099-1105
R215	Composition, 1.5 kΩ ±5% 1/4 W	6099-2155
R216	Potentiometer, composition 500 Ω ±20%	6040-0300
R217	Composition, 560 Ω ±5% 1/4 W	6099-1565
R219	Composition, 2.2 kΩ ±5% 1/4 W	6099-2225
R220	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R221	Composition, 330 Ω ±5% 1/4 W	6099-1105
R222	Composition, 47 Ω ±5% 1/4 W	6099-0475
R223	Composition, 15 Ω ±5% 1/4 W	6099-0155
R224	Composition, 33 Ω ±5% 1/4 W	6099-0335
R225	Composition, 150 Ω ±5% 1/4 W	6099-1155

TRANSISTORS

REF NO	DESCRIPTION	PART NO
Q101	Type 2N2188	8210-1045
Q102	Type 2N2218	8210-1028
Q103	Type 2N2218	8210-1028
Q104	Type 2N2218	8210-1028
Q105	Type 2N2218	8210-1028
Q201	Type 2N918	8210-1066
Q202	Type 2N3250	8210-1089
Q203	Type SE4002	8210-1077
Q204	Type 2N3250	8210-1089

MISCELLANEOUS

REF NO	DESCRIPTION	PART NO
CR201	DIODE, Semiconductor type 1N994	6082-1017
CR202	DIODE, Semiconductor type 1N994	6082-1017
CR203	DIODE, Semiconductor type 1N995	6082-1002
J101 through J103	JACK, Etched-circuit, type	1160-6110
J201 through J204	JACK, Etched-circuit, type	1160-6110
T101	TRANSFORMER, Adjustable	1160-2390
T201	TRANSFORMER, Adjustable	5000-2603
T202	TRANSFORMER, Adjustable	5000-2402

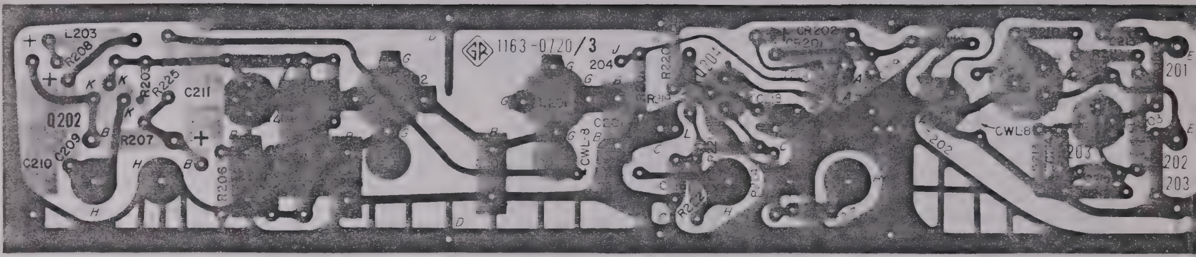

1163-0720/3
L203
R208
Q202
C209
C210
R207
C211
R225
R206
204
CWL-8
CR202
CR201
R220
201
202
203

Figure FC-4. Etched-circuit board of Preamplifier (P/N 1163-2720).

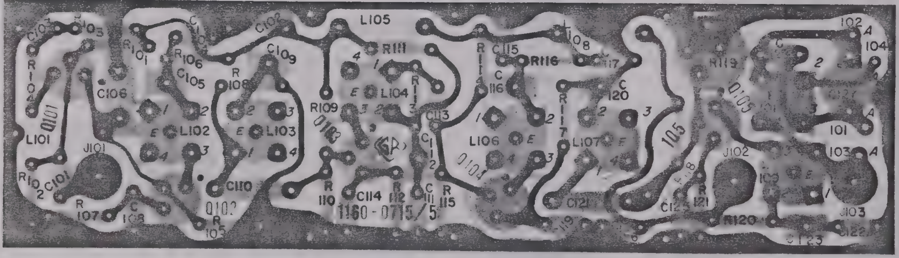
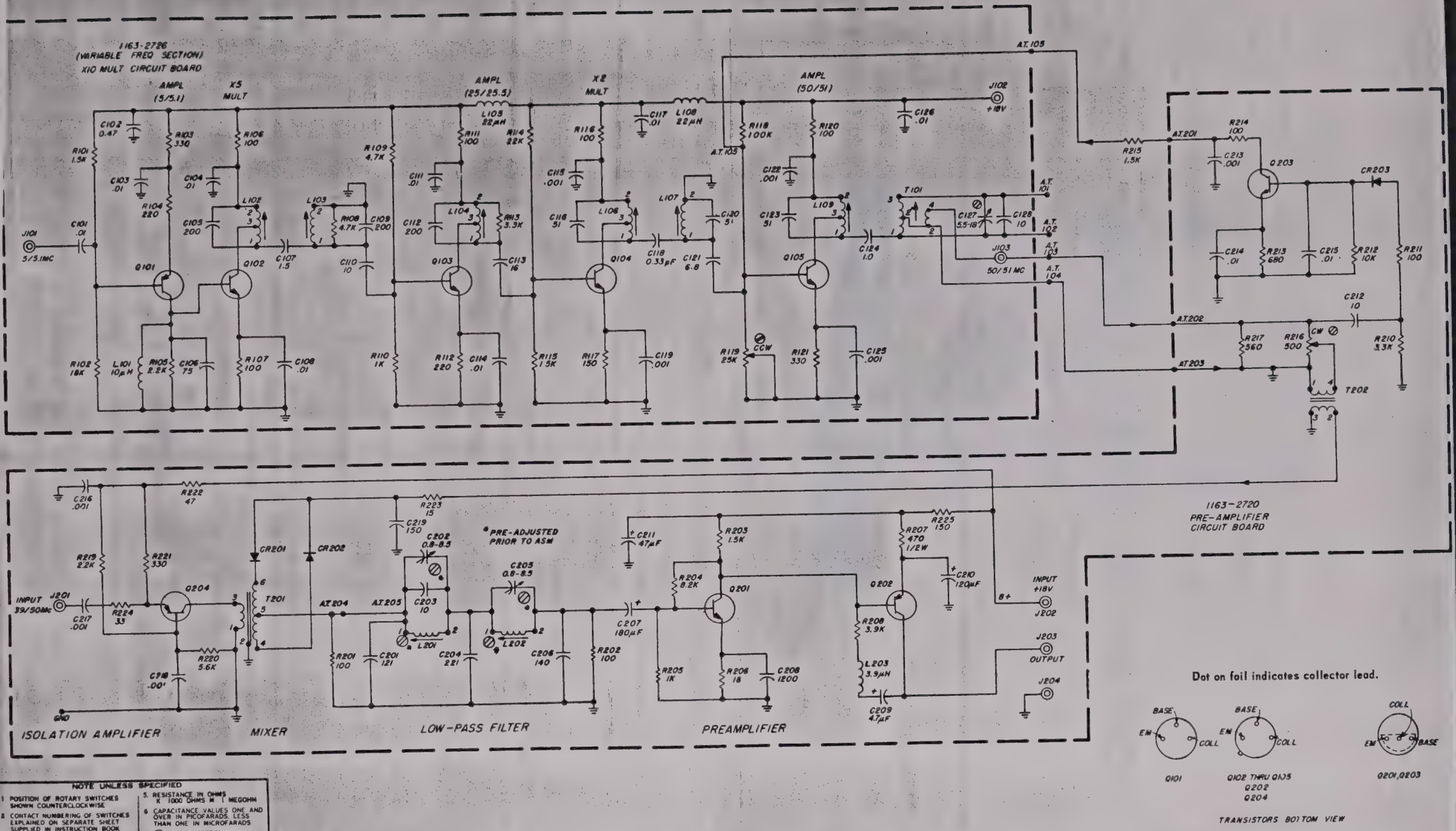

L105
C103
R103
R101
R106
C105
C102
C109
R108
R111
C115
R116
C116
R117
C120
R119
Q101
L101
J101
C106
L102
L103
R109
Q103
L104
C113
L106
L107
Q104
105
Q105
J102
101
103
J103
R102
C101
R107
C108
C110
Q102
R105
R110
C114
R112
C111
R115
1160-0715/5
C121
C125
R121
R120
C123
C122
102
104

Figure FC-5. Etched-circuit board of X10 Multiplier (P/N 1163-2726).

NOTE: The number appearing on the foil side is not the part number.


1163-2726
(VARIABLE FREQ SECTION)
X10 MULT CIRCUIT BOARD
AMPL (5/5.1)
X5 MULT
AMPL (25/25.5)
X2 MULT
AMPL (50/51)
J101 5/5.1MC
J102 +18V
J103 50/51 MC
A.T. 101
A.T. 102
A.T. 103
A.T. 104
A.T. 105
Q101
Q102
Q103
Q104
Q105
T101
R101 1.5K
R102 18K
R103 330
R104 220
R105 2.2K
R106 100
R107 100
R108 4.7K
R109 4.7K
R110 1K
R111 100
R112 220
R113 3.3K
R114 22K
R115 1.5K
R116 100
R117 150
R118 100K
R119 25K
R120 100
R121 330
C101 .01
C102 0.47
C103 .01
C104 .01
C105 200
C106 75
C107 1.5
C108 .01
C109 200
C110 10
C111 .01
C112 200
C113 16
C114 .01
C115 .001
C116 51
C117 .01
C118 0.33pF
C119 .001
C120 51
C121 6.8
C122 .001
C123 51
C124 1.0
C125 .001
C126 .01
C127 5.5-18.7
C128 10
L101 10μH
L102
L103
L104
L105 22μH
L106
L107
L108 22μH
L109
CCW
CW
A.T.201
A.T.202
A.T.203
Q203
CR203
R210 3.3K
R211 100
R212 10K
R213 680
R214 100
R215 1.5K
R216 500
R217 560
C212 10
C213 .001
C214 .01
C215 .01
T202
1163-2720
PRE-AMPLIFIER
CIRCUIT BOARD
INPUT 39/50MC J201
GND
Q204
T201
CR201
CR202
A.T.204
A.T.205
Q201
Q202
R201 100
R202 100
R203 1.5K
R204 8.2K
R205 1K
R206 18
R207 470 1/2W
R208 3.9K
R219 2.2K
R220 5.6K
R221 330
R222 47
R223 15
R224 33
R225 150
C201 121
C202 0.8-8.5
C203 10
C204 221
C205 0.8-8.5
C206 140
C207 180μF
C208 1200
C209 4.7μF
C210 120μF
C211 47μF
C216 .001
C217 .001
C218 .001
C219 150
L201
L202
L203 3.9μH
*PRE-ADJUSTED PRIOR TO ASM
B+
INPUT +18V J202
J203 OUTPUT
J204
ISOLATION AMPLIFIER
MIXER
LOW-PASS FILTER
PREAMPLIFIER
Dot on foil indicates collector lead.
BASE
EM
COLL
Q101
Q102 THRU Q105
Q202
Q204
Q201,Q203
TRANSISTORS BOTTOM VIEW

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

Figure FC-6. Over-all schematic diagram for Output Multiplier-Mixer – OMM-2 (P/N 1163-4010).

SERVICE INSTRUCTIONS

section GA

POWER SUPPLY MODULE – PS-1

P/N 1160-4050

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  GA-1.1 General — GA-3
  GA-1.2 Purpose — GA-3
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  GA-1.4 DC Power Input — GA-4

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  GA-3.3 Trouble Analysis — GA-6
  GA-3.4 Fuse Changes — GA-7
  GA-3.5 Removal — GA-7
  GA-3.6 Input-Power Conversion — GA-7

Form No. 1160-4050-A ID Number B4 March 1966

GENERAL RADIO COMPANY

West Concord, Massachusetts

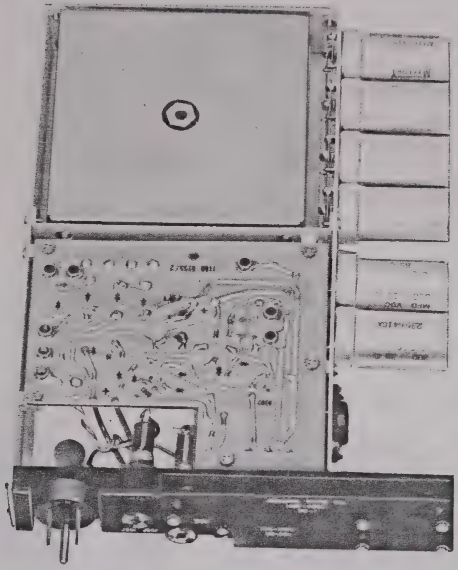


Figure GA-1.
PS-1 Power Supply module (P/N 1160-4050).

SECTION GA-1

INTRODUCTION

GA-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section is prepared with a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis."

Included in the following paragraphs are a physical description and operational discussion of the module sufficient for comprehension, by experienced service personnel, of the principles of operation. A trouble-analysis procedure that will aid in isolating the defective circuit completes the section.

To facilitate part identification, reference designators used in the text and appearing on the photograph are the same as those used on the complete schematic diagram and in the parts list. The reference designators are silk-screened on the module as a further aid in part location.

The service instructions are written to facilitate use of a properly functioning synthesizer as a basic test frame for the individual module. The instrument can be used to support the module, in a convenient bench-service position, and furnish controls and loads.

NOTE

> First consideration should be given to the use of the widespread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty coverage.

GA-1.2 PURPOSE.

The PS-1 Power Supply module is a compact, solid-state unit that is used in synthesizer Types 1161, 1162, and 1163. As with the other modules, it is a plug-in type and is completely interchangeable in all versions of these synthesizers.

TABLE GA-1

PRIME-POWER-INPUT CONFIGURATIONS

Line Voltage	*Frequency (c/s)*	*Power*	*Primary Fuse Rating (A)*	*Remarks*
105 - 125	50 - 400	55 W	0.8	See Figure GA-4 for input-transformer terminal selection.
195 - 235			0.4	
210 - 250			0.4	
20 - 28	dc	1.8 A	—	Refer to paragraph 2.2.2 (front portion of this manual.

TABLE GA-2
DC POWER OUTPUTS
(Figure GA-2)

Name	*Jack*	*Output Volts (dc)*	*Output Amperes*	*Use*
+18V #1	J507	+18, regulated	1.200	B+ for all modules plus auxilliary output at rear of Main Frame.
+18V #2	J506	+18, regulated	0.140	B+ for Picket Fence Section of AFS module only.
+18V #3	J508	+18, regulated	0.110	B+ for Output Amplifier and source needed to voltage tune the primary 5-Mc oscillator in the AFS.
+24V	J505	+24V, unregulated	0.250	Energizes lamps in all DI's and CAD module.

It can be energized from ac line sources ranging from 105 to 250 volts, or from a 20 to 28 volt dc primary input. Table GA-1 list various input-power arrangements. The appropriate ac power-input range, as determined by original factory wiring, is marked on the rear panel of the power supply to be plainly visible when the supply is in the synthesizer. Line frequency of ac inputs should not exceed the range 50 to 400 c/s.

The PS-1 supplies the entire power requirements for the synthesizer, including programming circuitry (refer to Table GA-2). In addition, it can supply auxilliary power for light loads.

GA-1.3 DESCRIPTION.

The PS-1 Power Supply module (see Figure GA -1) is a flat-shaped unit that mounts on the under side of the Main Frame chassis deck, at the right-hand side. It engages eight banana plugs protruding from the deck and is held in place by three 10-32 screws. Two captive screws attach to threaded inserts in the rear edge of the deck and a third screw attaches through the unit into the bottom of the deck. The plugs distribute the outputs and connect to primary input power and the front-panel POWER switch.

Rectifying and regulating circuitry consist entirely of solid-state devices, for the most part mounted on an etched-circuit board.

The power supply is designed to operate over a temperature range of 0 to 50° C. An open layout permits good ventilation in all parts of the unit; heat sinks of substantial capacity complete the thermal control.

Because of the sensitivity of synthesizer circuits to electromagnetic fields, special precautions are built into the power supply to restrict interference of this kind to a very low level. The primary input transformer is completely shielded in a high-permeability metal case to contain interfering fields.

A screwdriver-adjustable potentiometer, accessible through the rear panel of the supply, can be used for fine adjustment of the output voltage.

The primary ac input plug is a UL-approved three-wire type mounted on the rear surface, with a third terminal wired to case ground for user safety.

The module is protected by three replaceable fuses, in both input and regulator circuitry, to protect it and other modules and to eliminate shock hazard for operating personnel. Two 3AG Slo-Blo fuses in screw-type mounts protect both sides of the ac input line. They are replaceable from the rear panel. A third fuse at the input to the regulator circuitry, protects the unit from momentary overload, particularly accidental shorts at the lamp holders or at +18-V banana plugs during service. Mounted on the etched-circuit board, this fuse requires removal of the synthesizer cabinet for access for replacement.

GA-1.4 DC POWER INPUT.

The power supply can be energized from a 1.8-A source of 20 to 28 Vdc, if the input-power cord is removed and the positive side of the battery is attached to J551 on the rear panel. The negative side must be connected to the case. The synthesizer POWER switch is inoperative in this mode.

The external supply should be of low impedance, such as a storage battery, otherwise the regulator circuits may not start when its power switch is closed.

SECTION GA-2

PRINCIPLES OF OPERATION

GA-2.1 GENERAL (Figure GA-4).

The PS-1 power-supply module uses a conventional series-regulator circuit to stabilize the +18 V (all 3 outputs) and to obtain low ripple. In this regulator, transistor Q501 is directly in series with the load and is used as a variable impedance.

Control of the transistor is achieved by comparison of the output voltage with a Zener-diode reference (CR508/CR509), amplification of the difference (or error voltage), and application of this signal to the regulating transistor. The resulting loop affords tight control, which keeps the output voltage near 18 V for both input-voltage changes and load-current variations. Typical performance figures are 60 mV change for a load change from 0 – 1.5 A and 15 mV change for input voltage change of 110 – 120 V. Ripple voltage (120 c/s) is below 1 mV, as measured at J507 with a full load of 1.5 A.

GA-2.2 DETAIL DISCUSSION.

Fuse F503 protects the rectifier diodes and R509 from a short circuit in the lamp circuits. The regulator itself is short-circuit proof, but will supply more than 1.5 A while maintaining 18 V; certain overloads exceeding 2 A will cause F503 to blow.

C508, R504, R505 and CR506 consitute the starting circuit, which supplies a turn-on pulse only if C508 is initially discharged. It is for this reason that the regulator will not start, when power is applied after a shutdown, unless the lamp-circuit load is connected. This load discharges the capacitor bank consisting of C503 through C508.

For dc operation from a source with poor regulation, it is necessary to start the regulator by momentary connection of J552 to J551, after the latter has been connected to the dc source. The potential at C503 through C507 will rise too slowly, in this case, to form a proper starting pulse. C509 then takes the place of C508 and briefly raises the potential across R504 and R505.

R503 and C511 are a ripple-compensation network.

Diodes CR510 and CR511, which are found in the lower arm of the voltage divider, compensate the effect of the temperature coefficient of Q503 and the reference diodes CR508 and CR509.

Q504 and associated components protect the load from overvoltage. In the event of series-transistor failure (emitter-to-collector short), Q504 is turned on hard and the resulting current will blow F503. With normal operating voltage of 18.0 V, no current is drawn by Q504.

SECTION GA-3

SERVICE AND MAINTENANCE

GA-3.1 GENERAL.

Except for the replacement of primary line fuses, the synthesizer must be removed from its case before service can be performed on the power-supply module.

In the procedures that follow, the four outputs of the supply can be measured with the unit in place on the synthesizer, if the instrument is operated inverted on the test bench. The correct values are given in paragraph GA-3.2.

If the voltages are present, and within tolerance (or can be adjusted within tolerance with R511), the problem must be in system interconnecting wiring on the Main Frame chassis; reference must be made to sections BA or BB, as appropriate.

If the voltage indications are abnormal, detailed trouble analysis of the supply can be performed. Figure GA-2 shows the location of test points and the secondary control (R511).

Figure GA-3 is a composite view of the etched-circuit board found in the supply. Used in conjunction with the over-all schematic diagram, Figure GA-4, it should facilitate isolation of defective parts.

GA-3.2 MINIMUM PERFORMANCE CHECKS.

Look for +24 Vdc at J505, if lamp-circuits are inoperative (see Figure GA-2).

To check regulator performance on the synthesizer chassis, determine the ripple level and measure the 18-V output. If the output at J507 is +18 ±0.1 V, and the ripple is below 1 mV, it can be assumed safely that the regulator is fully operative. Voltages under load at outputs No. 2 and 3 are 17.95 ±0.1 V and 17.80 ±0.1 V, respectively. All voltages can be adjusted by R511, which is accessible from the rear of the supply.

GA-3.3 TROUBLE ANALYSIS.

Consult Table GA-3, for a listing of transistor voltages, to perform a detailed trouble analysis if unable to find the voltages indicated in paragraph GA-3.2.

Repair or replace defective parts. The parts list which follows gives the values of all electrical parts.

TABLE GA-3

DC VOLTAGES

(Figure GA-2)

Stage	*Emitter*	*Base*	*Collector*
Q501	22.0	21.8	18.0
Q502	21.8	21.2	17.4
Q503	6.8	7.4	10-21.0
Q504	18.0	18.0	0

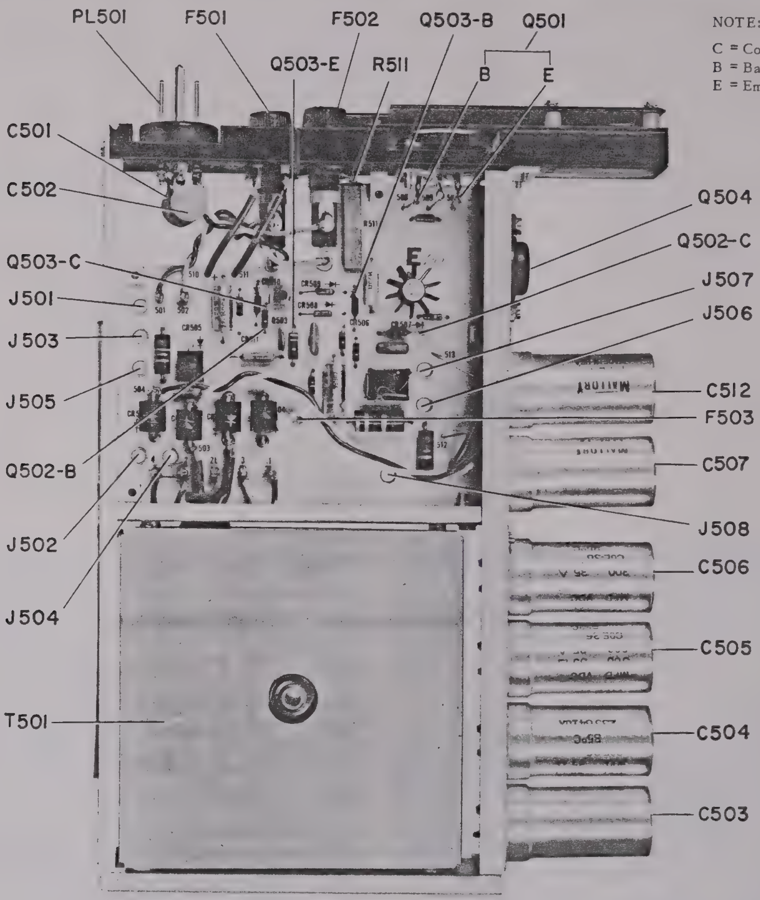
NOTES:

Unit operating in chassis (operating synthesizer).

Voltages measured with GR Type 1806-A (dc+position).

These are typical readings partly dependent on Zener-diode voltage tolerances; variations of ±10% are to be expected.

Q503 collector reading dependent on beta of Q501 and Q502.


PL501
F501
F502
Q503-B
Q501
Q503-E
R511
B
E
C501
C502
Q504
Q502-C
Q503-C
J507
J501
J506
J503
J505
C512
F503
C507
Q502-B
J508
J502
C506
J504
C505
T501
C504
C503

NOTE: Suffixes used:
C = Collector
B = Base
E = Emitter

Figure GA-2. Interior test points and secondary control for PS-1 module.

GA-3.4 FUSE CHANGES.

The fuses can all be removed from the module without having to remove the unit from the synthesizer. The primary line fuses, F501 and F502, are standard 3AG units that mount in screw-type extractor-post holders on the rear apron of the module.

F503 is a sub-miniature fuse mounted on the etched-circuit board, accessible from the bottom of the supply. Pull the fuse away from the board to remove it.

GA-3.5 REMOVAL.

The PS-1 module can be removed from the synthesizer chassis as follows:

a. Turn off synthesizer power.

b. Remove the synthesizer from its case and invert the instrument on the bench.

c. Remove the screw that passes through the center of the transformer, on the bottom surface of the module.

d. Release the two screws that fasten the supply to the rear apron of the synthesizer.

e. Lift the unit straight up, away from the deck, until the banana plugs are disengaged.

Installation is the reverse of removal.

GA-3.6 INPUT-POWER CONVERSION.

The power-supply module can be operated at any of three primary ac line voltages. Refer to the note on Figure GA-4 for wiring instructions.

PARTS LIST

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C501	Ceramic, 0.01 µF +80-20% 500 V	4406-3109
C502	Ceramic, 0.0068 µF +80-20% 500 V	4406-2689
C503AB	Electrolytic, 600 µF +100-10% 35 V	4450-2400
C504AB	Electrolytic, 600 µF +100-10% 35 V	4450-2400
C505AB	Electrolytic, 600 µF +100-10% 35 V	4450-2400
C506AB	Electrolytic, 600 µF +100-10% 35 V	4450-2400
C507AB	Electrolytic, 600 µF +100-10% 35 V	4450-2400
C508	Electrolytic, 10 µF +100-10% 25 V	4450-3800
C509	Electrolytic, 22 µF ±20% 35 V	4450-5612
C510	Ceramic, 0.01 µF +80-20% 50 V	4401-3100
C511	Ceramic, 1 µF ±20% 25 V	4400-2070
C512A	Electrolytic, 300 µF +100-10% 35 V	4450-2400
C512B	Electrolytic, 300 µF +100-10% 35 V	4450-2400
C513	Ceramic, 2.2 µF ±20% 25 V	4400-2080
	DIODES	
CR501	Semiconductor, type SOD100D	6081-1014
CR502	Semiconductor, type SOD100D	6081-1014
CR503	Semiconductor, type SOD100D	6081-1014
CR504	Semiconductor, type SOD100D	6081-1014
CR505	Semiconductor, type SOD100D	6081-1014
CR506	Semiconductor, type 1N645	6082-1016
CR507	Semiconductor, type 1N645	6082-1016
CR508	Semiconductor, type 1N752	6083-1004
CR509	Semiconductor, type 1N752	6083-1004
CR510	Semiconductor, type 1N645	6082-1016
CR511	Semiconductor, type 1N748A	6083-1002
CR512	Semiconductor, type 1N968B	6083-1018
CR513	Semiconductor, type 1N3253	6081-1001
	RESISTORS	
R501	Composition, 33 Ω ±5% 1/4 W	6099-0335
R502	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R503	Composition, 18 kΩ ±5% 1/4 W	6099-3185
R504	Composition, 3.3 kΩ ±5% 1/4 W	6099-2335
R505	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R506	Composition, 330 Ω ±10% 2 W	6120-1339
R507	Composition, 2.7 kΩ ±5% 1/4 W	6099-2275
R508	Composition, 330 Ω ±5% 1/2 W	6100-1335
R509	Resistor, wire-wound 6.8 Ω ±10% 2 W	6760-9689
R510	Resistor, film, 1.47 kΩ ±1% 1/4 W	6350-1147
R511	Potentiometer, wire-wound 500 Ω ±10%	6057-1509
R512	Resistor, film, 301 Ω ±1% 1/4 W	6350-0301
R513	Composition, 51 Ω ±5% 1/2 W	6100-0515
R514	Resistor, wire-wound 2.2 Ω ±10% 2 W	6760-9229
	MISCELLANEOUS	
F501	Fuse, 0.4A – 3AG type (220V and 230V)	5330-0900
F502	Fuse, 0.4A – 3AG type (220V and 230V)	5330-0900
F501	Fuse, 0.8A – 3AG type (115V)	5330-1200
F502	Fuse, 0.8A – 3AG type (115V)	5330-1200
F503	Fuse, 2.0A – subminiature	5330-5020
J501 through J508	Jack, etched-circuit type	1160-6110
J551	Jack, Phone, tip type	4260-0900
J552	Jack, Phone, tip type	4260-0900
L501	Inductor, choke	5000-2829
PL501	Plug, power, 3 wire	4240-0600
T501	Transformer, power, shielded toroid	1160-2500
Q501	Transistor, type 2N1540	8210-1540
Q502	Transistor, type 2N1131	8210-1025
Q503	Transistor, type 2N910	8210-1037
Q504	Transistor, type 2N1540	8210-1540

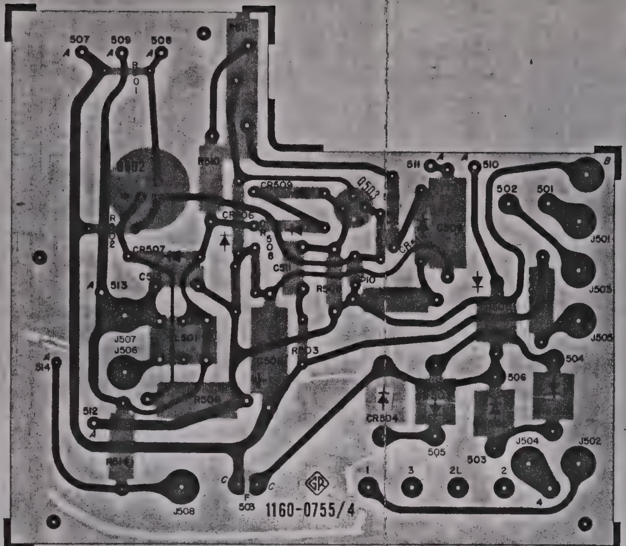
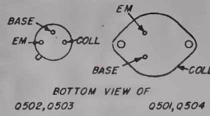

507
509
508
A
R
O
I
511
510
502
501
B
J501
J503
J505
504
506
J504
J502
505
503
2L
1
3
2
4
513
514
512
J507
J506
CR504
CR507
CR506
CR509
R510
C511
R503
R506
R514
J508
C
F
503
1160-0755/4
GR

Figure GA-3. Etched-circuit board assembly (P/N 1160-2755) for PS-1 Power Supply module.

NOTE: The number appearing on the foil side is not the part number.

Dot on foil indicates collector lead.


BASE
EM
COLL
EM
BASE
COLL
BOTTOM VIEW OF
Q502, Q503
Q501, Q504

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K · 1000 OHMS M 1 MEGOHM
6 CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

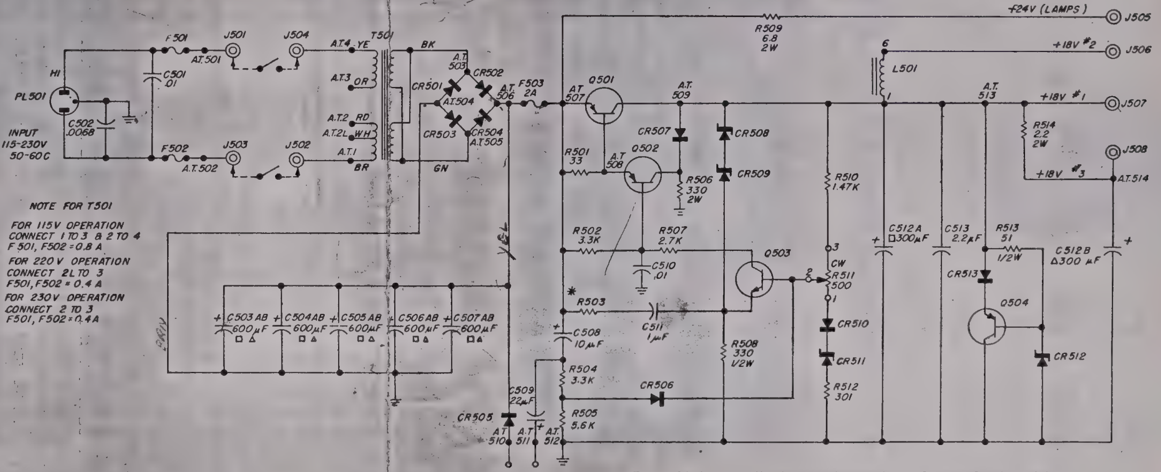
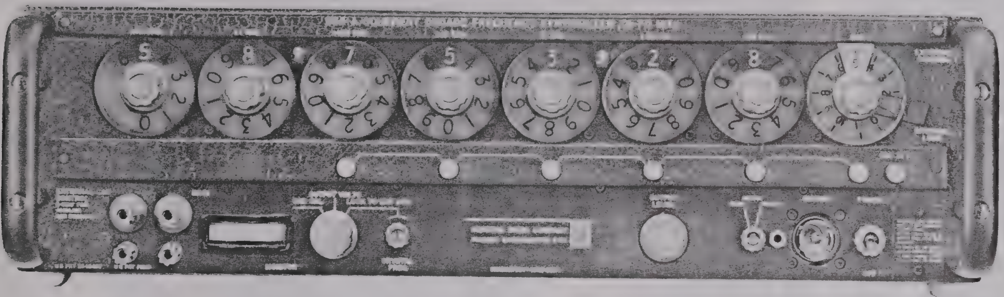

+24V (LAMPS)
J505
+18V #2
J506
+18V #1
J507
J508
+18V #3
AT 514
R509 6.8 2W
L501
6
1
A.T. 513
R514 2.2 2W
PL501
HI
INPUT 115-230V 50-60C
C502 .0068
C501 .01
F501
AT 501
J501
J504
F502
AT 502
J503
J502
A.T.4 YE
A.T.3 OR
A.T.2 RD
A.T.2L WH
A.T.1 BR
T501
BK
GN
A.T. 503
CR502
CR501
A.T.504
CR503
CR504
A.T.505
A.T. 506
F503 2A
A.T. 507
Q501
A.T. 509
CR507
CR508
CR509
R501 33
A.T. 508
Q502
R506 330 2W
R510 1.47K
R502 3.3K
R507 2.7K
C510 .01
Q503
3
CW
R511 500
2
1
CR510
CR511
R512 301
*
R503
C511 1µF
C508 10µF
R504 3.3K
R505 5.6K
R508 330 1/2W
CR506
C509 22µF
CR505
A.T. 510
A.T. 511
A.T. 512
J551
J552
C512A □300µF
C513 2.2µF
R513 51 1/2W
C512B Δ300 µF
CR513
Q504
CR512
C503AB 600µF □Δ
C504AB 600µF □Δ
C505AB 600µF □Δ
C506AB 600µF □Δ
C507AB 600µF □Δ
YEL
PRIV
NOTE FOR T501
FOR 115V OPERATION CONNECT 1 TO 3 & 2 TO 4 F501, F502 = 0.8 A
FOR 220 V OPERATION CONNECT 2L TO 3 F501, F502 = 0.4 A
FOR 230V OPERATION CONNECT 2 TO 3 F501, F502 = 0.4A

Figure GA-4. Over-all schematic diagram for PS-1 Power Supply module.

NEW 70-MHz Solid-State Synthesizer

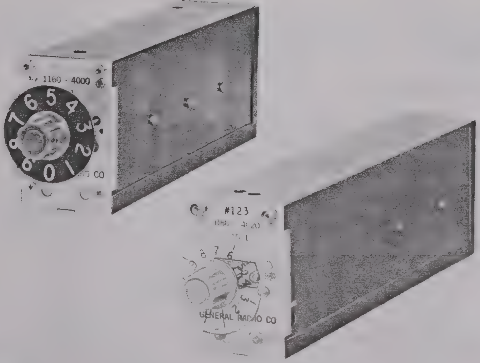


Available in 20 versions. Output adjustable up to 2 volts at accurately known, stable, sine-wave frequencies. 7-digit readout plus continuous frequency control. Signals are coherently synthesized from internal quartz-crystal oscillator. Plug-in modules give you choice of resolution: 10 Hz, 100 Hz, 1 kHz, and 100 kHz, or to better than 0.1 Hz with a continuously adjustable decade.

Basic Synthesizer Modules

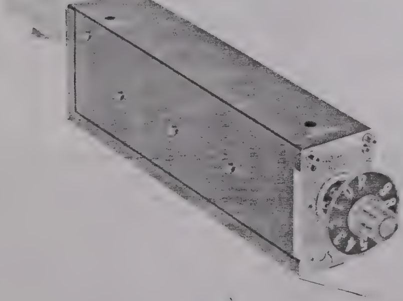
The DI-1 Unit

Digit-Insertion Module provides discrete frequency steps. This module is used for all digit decades except the 1-MHz and 10-MHz per-step positions.



The CAD Unit

Continuously Adjustable Decade provides either continuous, manual control of frequency or sweep-frequency coverage of selected sections of the instrument's range up to bandwidths of 1 MHz. It can also readily be calibrated against DI-1 Units to provide additional resolution.



The RDI-1 Unit

Remotely Programmable Digit-Insertion Module, used in place of the DI-1 Unit, converts the Synthesizer for programmed operation at any or all DI-1 stations. The RDI-1 Unit accepts either a biquinary or 10-line coded program or can be used manually when the dial is turned from the programmable "R" position to the desired digit. A plug is provided at the rear of the module for the programming signal.

SPECIFICATIONS

Frequency Range: 10 kHz to 70 MHz.

Smallest Digital Step: 10 Hz.

Smallest Direct-Reading CAD Increment (A7C model): 0.1 Hz.

Maximum Bandwidth Controllable by CAD: 1.2 MHz.

Maximum Programmable Bandwidth:** 1 MHz.

Spurious Frequency Outputs: Harmonic (at max output), <-30 dB. Nonharmonic, <-60 dB.

Output: 0 to 2 V, rms; metered; behind 50Ω; flat within 0.3 dB from 10 kHz to 70 MHz, available at either front or rear.

Auxiliary Outputs (at rear): *Primary outlets,* 100 kHz and 5 MHz (0.5 V, rms, min, across 50Ω). *Secondary outlets,* low-level, high-impedance, 0.1 V, min, across 1 kΩ: 1 MHz, 5 MHz, 5/5.1 MHz, 30 MHz, 42 MHz, 50/51 MHz, 90 MHz, and +18 V, dc (test point). BEAT output and EXT CAD CONTROL input also duplicated at rear.

Operating Temperature Range: 0 to 50°C.

Internal Frequency Standard: Room-temperature, quartz-crystal oscillator. Temperature coefficient of frequency is typically less than $2 \times 10^{-7}/°C$ from 20°C to 50°C. A front-panel frequency adjustment is provided. Crystal can easily be phase-locked to an external standard.

Lock Signal Input from external standard (if used): 0.25 V, rms, to 5 V, rms, 5 MHz, or any submultiple down to 100 kHz. Input impedance is approximately 1 kΩ for low-level signals, drops to approximately 50Ω effective at high levels.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 400 Hz, 55 W; or 20 to 28 V, dc, 1.8 A.

CALIBRATED DIGITS						PROGRAMMABLE/MANUAL MODELS**		
Type	**Units Included**	**DI Decades Only**	**DI Decades + CAD***	**Smallest Step (DI Only)**	**Price**	**Type**	**Smallest Programmable Increment**	**Price**
1164-A7C	7 DI Units + CAD	7	9	10 Hz	**6,600.00**	**1164-AR7C**	10 Hz	**7,025.00**
1164-A6C	6 DI Units + CAD	6	8	100 Hz	**6,160.00**	**1164-AR6C**	100 Hz	**6,500.00**
1164-A5C	5 DI Units + CAD	5	7	1 kHz	**5,720.00**	**1164-AR5C**	1 kHz	**5,975.00**
1164-A4C	4 DI Units + CAD	4	6	10 kHz	**5,280.00**	**1164-AR4C**	10 kHz	**5,450.00**
1164-A3C	3 DI Units + CAD	3	5	100 kHz	**4,840.00**	**1164-AR3C**	100 kHz	**4,925.00**
1164-A7	7 DI Units	7		10 Hz	**6,100.00**	**1164-AR7**	10 Hz	**6,525.00**
1164-A6	6 DI Units	6		100 Hz	**5,660.00**	**1164-AR6**	100 Hz	**6,000.00**
1164-A5	5 DI Units	5		1 kHz	**5,220.00**	**1164-AR5**	1 kHz	**5,475.00**
1164-A4	4 DI Units	4		10 kHz	**4,780.00**	**1164-AR4**	10 kHz	**4,950.00**
1164-A3	3 DI Units	3		100 kHz	**4,340.00**	**1164-AR3**	100 kHz	**4,425.00**

*Direct Reading. If CAD is calibrated in terms of the DI step decades, at least one more significant figure can be added.
**The X10 MHz and X1 MHz decade units are not programmable. However, these two decades can be programmed between whole 1-MHz steps (for example, between 11 and 12 MHz, 25 and 26 MHz, 59 and 60 MHz, etc).

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  Ridgefield, New Jersey 07657
- SYRACUSE
  Pickard Building, East Molloy Rd.
  Syracuse, New York 13211
- PHILADELPHIA
  Fort Washington Industrial Park
  Fort Washington, Pennsylvania 19034
- WASHINGTON and BALTIMORE
  11420 Rockville Pike
  Rockville, Maryland 20852
- CHICAGO
  6605 West North Avenue
  Oak Park, Illinois 60302
- CLEVELAND
  5579 Pearl Road
  Cleveland, Ohio 44129
- ORLANDO
  113 East Colonial Drive
  Orlando, Florida 32801
- DALLAS
  2600 Stemmons Freeway, Suite 210
  Dallas, Texas 75207
- SAN FRANCISCO
  626 San Antonio Road
  Mountain View, California 94040
- LOS ANGELES
  1000 North Seward Street
  Los Angeles, California 90038
- TORONTO
  99 Floral Parkway
  Toronto 15, Ontario, Canada
- MONTREAL
  1255 Laird Boulevard
  Town of Mt. Royal, Quebec, Canada

GENERAL RADIO COMPANY (OVERSEAS), 8008 Zurich, Switzerland

GENERAL RADIO COMPANY (U.K.) LIMITED, Bourne End, Buckinghamshire, England

REPRESENTATIVES IN PRINCIPAL OVERSEAS COUNTRIES

Form 3120-A1

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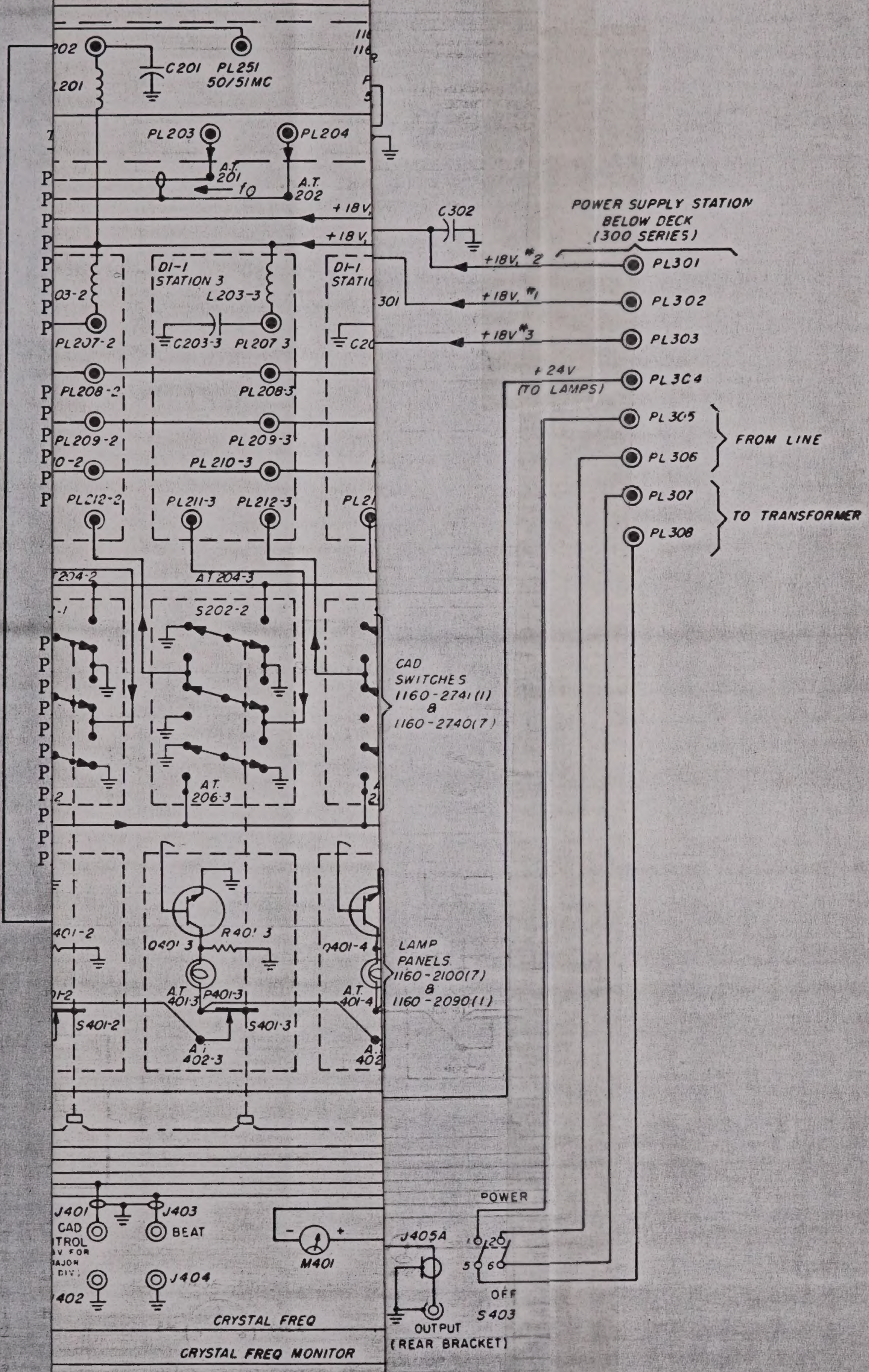
202
L201
C201
PL251
50/51MC
PL203
PL204
A.T.
201
f0
A.T.
202
+18V
+18V
C302
POWER SUPPLY STATION
BELOW DECK
(300 SERIES)
+18V, #2
PL301
+18V, #1
PL302
+18V #3
PL303
+24V
(TO LAMPS)
PL304
PL305
PL306
FROM LINE
PL307
PL308
TO TRANSFORMER
DI-1
STATION 3
L203-3
03-2
C203-3
PL207-2
PL207 3
DI-1
STATI
301
PL208-2
PL208-3
PL209-2
PL209-3
PL210-3
PL212-2
PL211-3
PL212-3
AT 204-3
S202-2
A.T.
206-3
CAD
SWITCHES
1160-2741(1)
&
1160-2740(7)
401-2
Q401 3
R401 3
Q401-4
LAMP
PANELS
1160-2100(7)
&
1160-2090(1)
A.T.
401-3
P401-3
A.T.
401-4
S401-2
S401-3
A.T.
402-3
J401
CAD
TROL
J403
BEAT
M401
J405A
POWER
OFF
S403
J404
402
CRYSTAL FREQ
CRYSTAL FREQ MONITOR
OUTPUT
(REAR BRACKET)

SPECIFICATIONS

Frequency Range: 10 kHz to 70 MHz.

Smallest Digital Step: 10 Hz.

Smallest Direct-Reading CAD Increment (A7C model): 0.1 Hz.

Maximum Bandwidth Controllable by CAD: 1.2 MHz.

Maximum Programmable Bandwidth:** 1 MHz.

Spurious Frequency Outputs: Harmonic (at max output), <-30 dB. Nonharmonic, <-60 dB.

Output: 0 to 2 V, rms; metered; behind 50Ω; flat within 0.3 dB from 10 kHz to 70 MHz, available at either front or rear.

Auxiliary Outputs (at rear): *Primary outlets*, 100 kHz and 5 MHz (0.5 V, rms, min, across 50Ω). *Secondary outlets*, low-level, high-impedance, 0.1 V, min, across 1 kΩ: 1 MHz, 5 MHz, 5/5.1 MHz, 30 MHz, 42 MHz, 50/51 MHz, 90 MHz, and +18 V, dc (test point). BEAT output and EXT CAD CONTROL input also duplicated at rear.

Operating Temperature Range: 0 to 50°C.

Internal Frequency Standard: Room-temperature, quartz-crystal oscillator. Temperature coefficient of frequency is typically less than 2×10^{-7}/°C from 20°C to 50°C. A front-panel frequency adjustment is provided. Crystal can easily be phase-locked to an external standard.

Lock Signal Input from external standard (if used): 0.25 V, rms, to 5 V, rms, 5 MHz, or any submultiple down to 100 kHz. Input impedance is approximately 1 kΩ for low-level signals, drops to approximately 50Ω effective at high levels.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 400 Hz, 55 W; or 20 to 28 V, dc, 1.8 A.

CALIBRATED DIGITS						PROGRAMMABLE/MANUAL MODELS**		
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*Direct Reading. If CAD is calibrated in terms of the DI step decades, at least one more significant figure can be added.

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  Oak Park, Illinois 60302
- CLEVELAND
  5579 Pearl Road
  Cleveland, Ohio 44129
- ORLANDO
  113 East Colonial Drive
  Orlando, Florida 32801
- DALLAS
  2600 Stemmons Freeway, Suite 210
  Dallas, Texas 75207
- SAN FRANCISCO
  626 San Antonio Road
  Mountain View, California 94040
- LOS ANGELES
  1000 North Seward Street
  Los Angeles, California 90038
- TORONTO
  99 Floral Parkway
  Toronto 15, Ontario, Canada
- MONTREAL
  1255 Laird Boulevard
  Town of Mt. Royal, Quebec, Canada

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TABLES OF INTERCONNECTIONS

Top Deck	Mating Connector	Mating Unit
PL201	J101	Output Mixer OM-1
PL202	J102	(See Section FA –
PL203	J202	for Type 1161-A)
PL204	J201	or
PL205	J102A	Output Multiplier-Mixer
PL206	J101A	OMM-1 (See Section FB
PL250		— for Type 1162-A)
PL251	J103A	For OMM-1 only
	J103	
PL207-N	J301	Digit Insertion Unit DI-1
PL208-N	J302	(7 Installed)
PL209-N	J303	(See Section DA)
PL210-N	J306	
PL211-N	J304	
PL212-N	J305	

Top Deck	Mating Connector	Mating Unit
PL213	J101	Cont. Adj. Decade CAD-1
PL214	J403	(See Section EA)
PL215	J402	
PL216	J404	
PL217	J102	
SO201 (terminals 1-6)	PL101 (terminals 1-6)	Calibrating Mixer CM-1 (See Section EA)

Bottom Deck	Mating Connector	Mating Unit
PL101	J201	Ancillary Frequency
PL102	J202	Source AFS-1
PL103	J105	(See Section CA)
PL104	J204	
PL105	J205	
PL106	J203	
PL107	J106	
PL108	J104	
PL109	J301	
PL110	J103	
PL111	J101	

Bottom Deck	Mating Connector	Mating Unit
PL301	J506	Power Supply PS-1
PL302	J507	(See Section GA)
PL303	J508	
PL304	J505	
PL305	J501	
PL306	J503	
PL307	J502	
PL308	J504	

NOTE UNLESS SPECIFIED

1 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE

2 CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK

3 REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM

4 RESISTORS 1/4 WATT

5 RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM

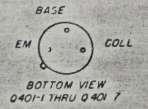
6 CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.

7 ○ KNOB CONTROL

8 ○ SCREWDRIVER CONTROL

9 AT ANCHOR TERMINAL

10 TP TEST POINT


BASE
EM
COLL
BOTTOM VIEW
Q401-1 THRU Q401 7

* NOTE
S404 EXISTS ONLY WHEN CAD-1 MODULE IS IN PLACE, AND IS MECHANICALLY GANGED WITH S101 OF THE CAD-1 MODULE

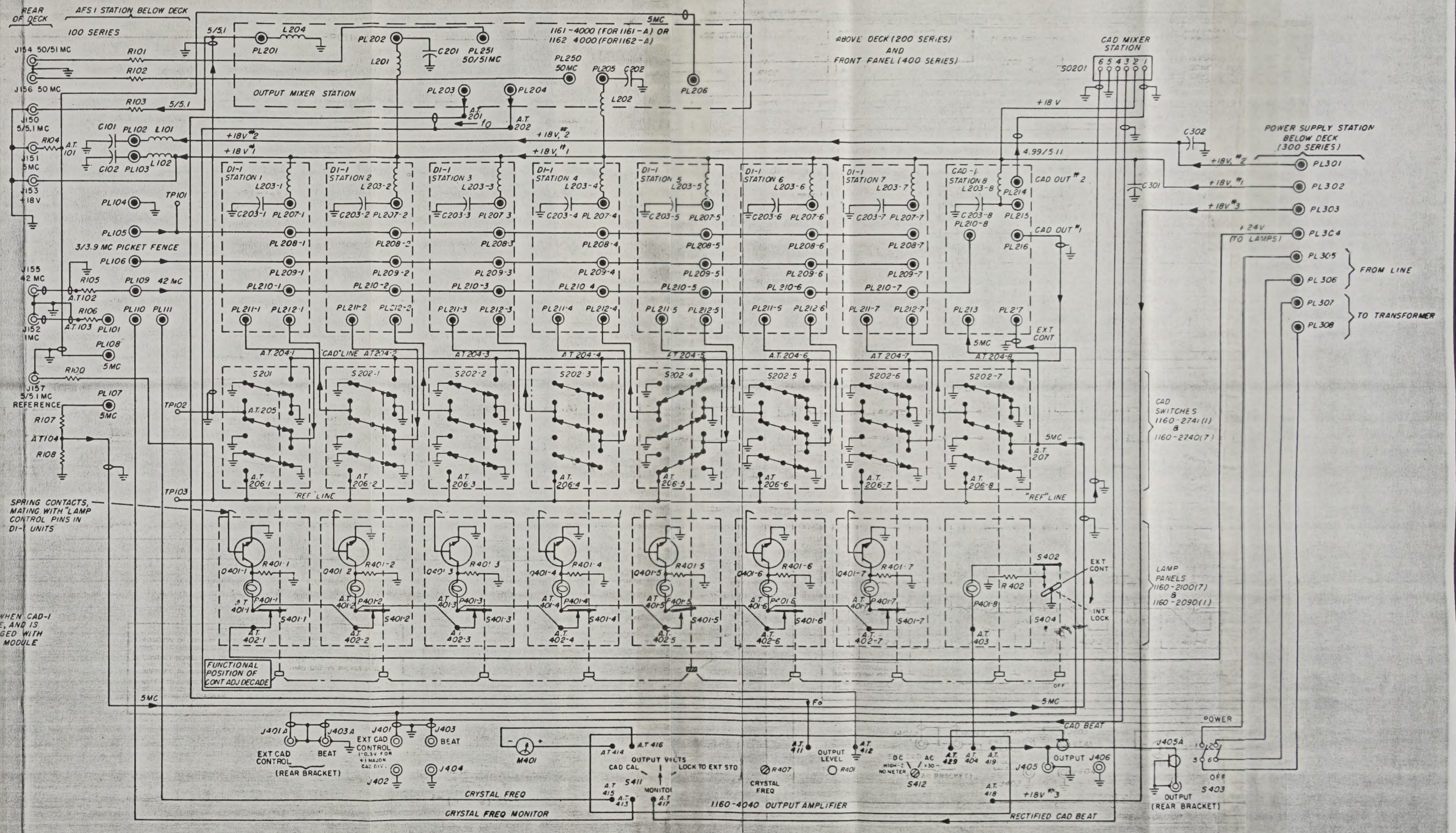

REAR OF DECK
AFS I STATION BELOW DECK
100 SERIES
J154 50/51 MC
J156 50 MC
J150 5/5.1 MC
J151 5MC
J153 +18V
J155 42 MC
J152 1MC
J157 5/5.1 MC REFERENCE
R101
R102
R103
R104
R105
R106
R107
R108
R100
A.T. 101
A.T. 102
A.T. 103
A.T. 104
C101
C102
L101
L102
PL101
PL102
PL103
PL104
PL105
PL106
PL107
PL108
PL109
PL110
PL111
TP101
TP102
TP103
3/3.9 MC PICKET FENCE
42 MC
5MC
5/5.1
OUTPUT MIXER STATION
1161-4000 (FOR 1161-A) OR 1162 4000 (FOR 1162-A)
PL201
PL202
PL203
PL204
PL205
PL206
PL250 50MC
PL251 50/51MC
L201
L202
L204
C201
C202
A.T. 201
A.T. 202
fo
+18V #2
+18V #1
ABOVE DECK (200 SERIES) AND FRONT FANEL (400 SERIES)
DI-1 STATION 1
DI-1 STATION 2
DI-1 STATION 3
DI-1 STATION 4
DI-1 STATION 5
DI-1 STATION 6
DI-1 STATION 7
CAD-1 STATION 8
L203-1
C203-1
PL207-1
PL208-1
PL209-1
PL210-1
PL211-1
PL212-1
PL213
PL214
PL215
PL216
PL217
PL210-8
CAD OUT #2
CAD OUT #1
EXT CONT
4.99/5.11
+18 V
CAD MIXER STATION
SO201
6 5 4 3 2 1
C301
C302
POWER SUPPLY STATION BELOW DECK (300 SERIES)
+18V #2
+18V #1
+18V #3
+24V (TO LAMPS)
PL301
PL302
PL303
PL304
PL305
PL306
PL307
PL308
FROM LINE
TO TRANSFORMER
"CAD" LINE
A.T. 204-1
S201
A.T. 205
S202-1
S202-2
S202-3
S202-4
S202-5
S202-6
S202-7
A.T. 206-1
"REF" LINE
A.T. 207
CAD SWITCHES 1160-2741 (1) & 1160-2740 (7)
SPRING CONTACTS, MATING WITH "LAMP CONTROL PINS IN DI-1 UNITS
Q401-1
R401-1
P401-1
A.T. 401-1
S401-1
A.T. 402-1
P401-8
R402
S402
S404
A.T. 403
EXT CONT
INT LOCK
LAMP PANELS 1160-2100 (7) & 1160-2090 (1)
FUNCTIONAL POSITION OF CONT ADJ DECADE
OFF
J401A
J403A
J401
J403
J402
J404
EXT CAD CONTROL
BEAT
(REAR BRACKET)
EXT CAD CONTROL 1-0.3V FOR +1 MAJOR CAD DIV.
M401
A.T. 414
A.T. 416
A.T. 415
A.T. 413
A.T. 417
OUTPUT VOLTS
CAD CAL
LOCK TO EXT STD
S411
MONITOR
R407
CRYSTAL FREQ
OUTPUT LEVEL
R401
A.T. 411
A.T. 412
DC HIGH-Z NO METER
AC >30~
S412
A.T. 429
A.T. 404
A.T. 419
A.T. 418
J405
OUTPUT J406
+18V #3
CAD BEAT
RECTIFIED CAD BEAT
CRYSTAL FREQ
CRYSTAL FREQ MONITOR
1160-4040 OUTPUT AMPLIFIER
J405A
OUTPUT (REAR BRACKET)
POWER
OFF
S403

Figure BA-9.
Over-all schematic diagram for Main Frame Chassis 1160-4060.